THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL.

VOL. 26. Thursday, December 7th, 1922. No. 329.

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial, 17s. 6d. per annum.
All Subscriptions are payable in advance.

All communications to be addressed to the Editor, or to the Publisher, as the case may be, of

THE FOUNDRY TRADE JOURNAL,
BESSEMER HOUSE, 5, DUKE STREET, ADELPHI,
LONDON, W.C.2.

Contents.

	PAGE
Blowholes	457
Sheffield as the Centre of the Refractories Industry	458
Birmingham Metallurgical Society	458
How Quality is Produced under Quantity Production Conditions	459
Institution of British Foundrymen—	
Cupola Receivers	462
Blow-Holes	463
Blow-Holes: Their Cause and Cure	463
Making a Skin-Dried Clutch Mould	465
Some Casting Problems of Acid-Resisting Irons	466
Working Slags	470
Gating, Feeding and Casting	471
An Apprenticeship Course in Foundry Practice—XXI.	473
"Perfect" Castings	474
Manufacture of Synthetic Cast-Iron in the Electric Furnace	475
London Branch Annual Dinner	475
Paris Congress and Exhibition	475
Trade Talk	475
Iron and Steel Markets	476
Gazette	478
Company News	478
Personal	478

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institution of British Foundrymen.

PRESIDENT, 1922-1923, Mr. H. L. Reason, M.I.Mech.E., Holloway Head, Birmingham.

LIST OF SECRETARIES—

General Secretary: W. G. Hollinworth, 38, Victoria Street, London, S.W.1.

Lancashire: T. Makemson, 21, Beresford Road, Gorse Hill, Stretford, Manchester.

Birmingham: D. Wilkinson, 1,114, Bristol Road, Northfield, Birmingham.

Sheffield and District: W. A. Macdonald, 62, Bannerdale Road, Sheffield.

Scottish: W. H. Bound, 69, Minard Road, Shawlands, Glasgow.

London: V. C. Faulkner, 21, Stanley Gardens, W.11.

Newcastle-on-Tyne: H. A. J. Rang, 2, St. Nicholas Buildings, Newcastle-on-Tyne.

East Midlands: H. Bunting, 17, Marcus Street, Derby.

Coventry: J. M. Meston, 37, Melville Road.

West Ridings of Yorkshire Branch: A. Love, 232, Gladstone Street, Bradford.

Welsh Engineers' and Founders' Association.

Secretary: E. J. Griffiths, 20, Fisher Street, Swansea.

Blow-Holes.

This week the subject of blow-holes assumes much importance in our columns, as not only is it dealt with under that caption by Messrs. Field and Wilkinson, but also Mr. E. Longden, in his Paper on "Gating, Feeding and Casting," has dealt very thoroughly with the matter. We agree with Mr. Wilkinson that the term should be confined to defects which can be definitely ascribed to gases evolved by the metal, *per se*, or through its reaction with the sand.

We fail to see on what basis Mr. Wilkinson assumes the production of Fe_3O_4—the magnetic oxide. This compound can also be written as $FeO.Fe_2O_3$, and we are of opinion, based on the presence of large quantities of reducing media, that if such a compound was formed it would only be momentarily, and that it is far more likely that any steam present would react as in equation (i):

$$(i)\ Fe + H_2O = FeO + H_2.$$

As is stated, a large portion of the iron consists of Fe_3C, and we put forward equation (ii) as representing the reaction between the ferrous oxide and the carbide.

$$(ii)\ Fe_3C + FeO = 2Fe_2 + CO.$$

To our mind, what happens when the molten iron touches the sand is that primarily the gases rush in front of the iron without reaction, except where they are forced to bubble through it. However, before the gas (steam) meets the iron it has to pass through a stratum of hot carbon in the form of blacking or other dressing. This being so, the steam would be broken up before it reaches the iron, as in equation (iii):—

$$(iii)\ H_2O + C = CO + H_2.$$

Now it is quite conceivable, as has been pointed out by the contributors to the subject, that cupola or any iron may carry ferrous oxide, and the two reducing agents would react with the oxide, reducing it to its metallic condition with the production of carbon dioxide and vapour; these would be reduced again by the carbon and other elements. It will readily be seen that a cycle of reactions may be taking place in rapid succession. Unfortunately, our knowledge of high temperature chemistry is limited, and we are apt to infer that reactions similar to those taking place at a less elevated temperature are maintained. Before leaving Mr. Wilkinson's Paper we would point out that the blue flame found at the joints of moulding boxes can also be attributed to the ignition of carbon monoxide.

We have laid some stress on the importance of the film of carbon on the surface of the sand as preventing the entrance of steam as such into the liquid metal, and some verification of this can be established by the comparison of a subcutaneous blow-hole which has been near to a good blacking facing and one from the proximity of a mould face not so treated. In the former case they will be silvery and in the latter tarnished with temper colours, thus showing signs of oxidation. Another function of this carbon film is to prevent the oxidation of a film of the metal surface to ferrous oxide, because in this state it would form a fusible slag with the silica of the mould, as in equation (iv):—

$$(iv)\ FeO + SiO_2 = FeO.SiO_2.$$

Thus it can be deduced that a casting showing a good skin on the surface next the mould has not passed any considerable quantity of steam through the body of the metal. When high temperature chemistry is better understood it is highly probable that definite equilibria will be established which will set out the necessary factors which will require to be balanced to eliminate these very objectionable blow-holes. Brinell made a very interesting study of blow-holes in Swedish Bessemer ingots, and could so control them as to place them in any position from the centre of the ingot to subcutaneous. Cast iron is, however, so complicated and of a relatively cheap nature as compared with steel that for the present the best practice for the foundryman to follow is to teem his castings with a metal of a temperature varying indirectly with the weight of the casting—high heat for small castings and low for large work.

Sheffield as the Centre of the Refractories Industry.

By F. G. S.

Amongst other important factors which have contributed to make Sheffield the acknowledged centre of the world's trade in the finer steels is the geological fact that it stands as almost the centre of a district producing the raw minerals necessary for the manufacture of refractory materials, in which term are included firebricks and fire-resisting linings of all kinds.

On the West of Sheffield the carboniferous limestone hills of Derbyshire, which, incidentally, contain in their folds and caves, veins of fluorspar, which is used not only in Sheffield and other British steel-producing centres, but in Canada and the United States as a flux of steel, are also rich in certain places in a deposit of siliceous sand, which, when made into bricks, has proved itself of exceptional value to certain departments of local industry, and which is worked at a number of pits near the High Peak Railway in most remote and exposed positions.

As the mountain limestone dips down to the east it is overlain by the massive escarpment of the millstone grit, which makes such bold features in the landscape as the hill at Matlock on which Riber Castle stands. The upper beds contain at Ambergate a thick seam of hard ganister rock, and when these millstone-grit beds dip down in their turn below the lower coal measures the true hard black or Sheffield ganister, with beds of fireclay immediately below it and a short distance above it, outcrops at many points, such as Dore, Totley, Stocksbridge, Deepcar, Oughtibridge, and other places quite near to Sheffield. This ganister is in great demand for the well-known Sheffield silica brick which is made in the Don Valley, and has a reputation for its high quality which covers the whole of the civilised world. The fireclays are mined and manufactured near Sheffield at Stannington, Loxley, Deepcar, Stocksbridge, Chesterfield, and many other points, and are converted into the bricks which, amongst other uses, line the ladles into which Sheffield's monster steel furnaces are emptied; into the fireclays of which the crucibles necessary for the manufacture of the very best and finest steel in the world are composed, and, indeed, into firebricks of all shapes and sizes, which are sent all over the world for lining stopper rods, in ladles, domestic firebacks, sides and cheeks, and a thousand and one other uses for all kinds of metallurgical and manufacturing operations. Out of the better quality of the Sheffield ganister is made the rough paste which forms the lining of the crucible steel furnaces, and a similar paste known as ground ganister, and consisting of a mixture of the lump ganister rock with fireclay, is exported to India, South America, South Africa and even Australia for the lining of foundry cupolas and the patching and repairing of furnaces of every description. There are in Great Britain over three thousand iron foundries, and it is no exaggeration to say that fully two thousand five hundred of these draw their supplies for lining their cupolas from Sheffield and the Sheffield district.

Sheffield's reputation for this particular furnace lining is such that users are almost everywhere agreeable to pay a higher price for it than for any competing material.

Turning to the steel foundries in all parts of the kingdom, their compositions and sands almost all emanate from Sheffield or its near vicinity. Sheffield "compo." has a national reputation, and many a steel foundry in Scotland and the Tyne and Tees district would be in a dilemma if supplies produced or originated in Sheffield were not available.

Going a little further west, and leaving out of consideration the particular coal which is ground up to make a fine coaldust essential in the production of first-class iron castings and the unique furnace coal in demand all over the country for certain metallurgical operations, we pass through the coal measures to the outcrop of the dolomite which runs north and south in a line from Sunderland to Nottingham only a few miles from Sheffield. It is worked and burnt into what is known as "basic," a material absolutely essential for the production of cheap steel by means of the basic process, and also for making the bottoms, or hearths, of basic electric furnaces, of which there are now so many in the City of Sheffield. This local "basic" is sent out to the large steel furnaces throughout the country, the value and importance of this business being hardly perhaps sufficiently recognised. Still within the radius of Sheffield influence, and only a few miles further west, there is the Worksop and Mansfield sands, and what ironfounder, be he making wringing machines in Keighley, malleable castings in the Black Country, or pulleys in Manchester, does not know the name of Mansfield? Worksop sand is almost as well known, and vast quantities of both are despatched every year, a great deal of it through firms operating from Sheffield. By virtue of the knowledge obtained locally, Sheffielders have been responsible for the financing and exploitation of such minerals as those just mentioned in all parts of the country, and indeed the world, and though one could instance numerous other examples of the value of local minerals to the metallurgical, gas, glass and engineering businesses, sufficient has perhaps been said to enable readers to realise that though refractory materials are not so much in the public eye as steel and its products, the business in them is nevertheless of "key" value to the whole world, and the annual turnover not one to be despised when regarded as a contribution to the city's income.

Birmingham Metallurgical Society.

At a meeting of the Birmingham Metallurgical Society, held at the Chamber of Commerce, on Thursday, November 30, MR. A. R. PAGE, of the B.S.A. Company, Limited, read a Paper on the subject of high-speed steels, the President (Mr. A. J. G. Smout) being in the chair.

After referring to the highly complex nature of the subject, and briefly outlining the history of high-speed steel, Mr. Page discussed the various theories that had been advanced during the past 20 years in order to explain the properties of these steels, and summed up existing knowledge of the matter.

The important subject of hardening and tempering high-speed steels was dealt with in detail, and attention called to the great care necessary for their successful treatment. It was stated that ideal hardening produced a steel showing under the microscope a small grained polygonal structure possessing an austenitic appearance. The effect of tempering was shown and reference made to the phenomenon of "secondary hardening." The author pointed out that there is very great need for some simple test whereby tools can be checked, in order to be sure the best treatment has been successfully carried out and that the cutting properties of the steel are satisfactory. In this connection file and Brinell hardness tests were often misleading, and bore little or no relationship to the cutting properties.

Mechanical methods of testing were discussed, notably drilling tests and the tool steel testing machine. The Paper was well received, and was followed by an interesting discussion of the whole subject.

Saving Energy in Compressed-Air Plants.—In a recent article in "Glückauf," Herr A. Hinz, of Essen, mentions a new design of compressed-air motor in which the exhaust is effected by means of slotted ports in the cylinder controlled by the piston. The expanded and cooled air escapes on the opposite side of the cylinder to the inlet, and cools the inlet ports. The residual air escapes through a special channel until the period of high compression commences. The residual air is again heated up to a greater extent than it was cooled down, and this due to the higher compression ratio. The freshly compressed air admitted mixes with the warmer residual air, so that, at the commencement of expansion, the temperature is higher than it is in the inlet pipe. In this way the compressed air is preheated, and this diminishes the risk of freezing, besides decreasing the air consumption. The 20-h.p. compressed-air motor in question is now at work, and troubles due to the formation of ice are eliminated, the consumption of air being about 1,230 to 1,400 cub. ft. per h.p.-hour.

How Quality is Produced under Quantity Production Conditions.*

By H. Cole Estep (European Manager of "The Foundry").

In European eyes "mass production" seems to be the chief characteristic of American industry, with emphasis on the number of articles made rather than their quality. It is only natural, perhaps, when viewing modern manufacturing methods in which a huge volume of production is the most spectacular but by no means the most important feature, for some people to make mental, if not verbal, reservations as to the quality of the goods turned out. A large number of American engineering writers have laid great stress on the speed of present-day methods, at the same time explaining how most of the operations can be entrusted to what is termed "unskilled" labour. In view of this it is not surprising to find in many quarters an impression that the goal of the average manufacturer in the United States is quantity, and quantity only.

What the author hopes to show more or less clearly, especially as applied to the foundry business, is that organisation for a large output is worse than useless unless accompanied by an elaborate, carefully constructed and constantly energised system of checks and control, whereby it is made not probable, but certain, that the article manufactured, be it a casting or a shoelace, will meet certain predetermined standards. It is in these considerations, rather than mere volume, that the philosophy of modern manufacturing is found.

If this philosophy is traced to its source, it is found that the somewhat different conceptions of manufacturing which exist in Great Britain and the United States are due, not to material considerations, but to differences in mental attitude, and if we each can only seek to understand these intangible factors we shall appreciate each other's problems more thoroughly, and thus at one stroke contribute something not only to the progress of engineering but to the comity of nations.

* A Paper read before the West Riding of Yorkshire Branch of the Institution of British Foundrymen.

A Purely British Term.

The term "mass production" is purely British in origin and use. It is seldom heard in American manufacturing circles. People on the other side of the Atlantic prefer to say "quantity production." Superficially, it appears to be another way of saying the same thing, but there is a distinction between the two terms, and one which finds its origin in the slightly different mental attitude of the two peoples toward manufacturing processes; and therefore an exact understanding of these two phrases may help to explain the psychology which has produced them.

In Webster's dictionary "quantity" is not found as a synonym of "mass." "Mass" conveys the idea of a lump, in which the individual particles taken one by one are of no account, and are effective, impressive or useful only in the aggregate or mass. "Quantity," on the other hand, means simply a collection of individual things; it involves the idea of number rather than of bulk, and under this conception the unit is of much more importance.

So perhaps with manufacturing. If a European foundryman is inclined to look on the casting of 2,000 motor-car cylinder sets per day as "mass production," his conception may not be quite the same as that of his American confrère who thinks of it as "quantity production" and knows that each casting must separately pass certain tests before it is acceptable for use, and must in service give 50,000 miles wear before regrinding.

A Soil-pipe Rigging. The two Cast-iron Patterns are Mounted on a Truck at a Convenient Height for Ramming by Hand. As the Truck Moves Along the Moulds are Placed Across the Rails and are thereby Automatically Levelled.

Scientific Control Basis of Quantity Production.

What the writer desires to make clear before outlining details connected directly with the foundry business is that large output alone is only the first and, in some aspects, the least important step in quantity production. In so far as this applies to the American foundry industry, it is found that its problems to-day are concerned

not so much with increasing production as with the perfection of methods of control whereby the castings now being made will meet the most rigid specifications and satisfy the most exacting demands with the same uniformity as the more elementary requirements of interchangeability is fulfilled. Research and control are the two channels through which American manufacturers are striving to reach their true goal, which is the production of quality goods on a quantity basis.

Nor is this a question of ethics, for the adoption of high standards is necessary from business considerations. Under quantity production conditions, the risk involved in turning out an inferior product is far greater than in the case of a small business, on account of the greater momentum of the large factory, if for no other reason. A certain automobile company in the Middle West of America was nearly ruined through turning out an inferior back axle for a single season. Examples of this sort could be multiplied. The necessity for giving constant thought to the kind of goods produced, if quantity manufacturing is to succeed, is made more clear by considering for a moment what modern outputs really mean. To start with a basic commodity such as pig-iron, the American production of this material at the present time is about two and a half million tons per month. In other words, the output of the United States in nine or ten weeks is about the equivalent of that in Great Britain, under existing conditions, in a year.

THE STRAIGHT LINE SYSTEM OF MOULDING CAST IRON CAR WHEELS. THE METAL IS CARRIED ALONG THE LINES OF MOULDS ON OVERHEAD TROLLEYS.

Thousands of Tons per Day.

More spectacular is the production of the automobile industry. The average production of passenger cars so far this year has been 170,000 a month, or at the rate of a little over 2,000,000 cars a year. The lowest output—in January—was 70,000 cars, and the highest—in June—263,000. To this must be added an average of 17,500 trucks per month—5,000 in January and 25,000 in June—making the total production of the country 288,000 vehicles in the latter month. Translated into foundry terms, this output means 11,000 sets of cylinder castings per working day, together with an equal number of flywheels and transmission cases, about 60,000 pistons, and 180,000 piston rings. This means melting and pouring over 3,000 tons of iron a day, and making the moulds into which to pour it.

Impressive as these figures are, they represent only one branch of the American foundry business. Another branch, the cast-iron railway truck wheel foundries, melts over 3,500 tons a day. Equally large is the melt of those foundries connected with the heating, plumbing, steam and gas fitting trades. Amongst the steel foundries there is one group of five shops delivering 2,569,327 castings to their customers in a single year, or about 1,600 a day from each plant. The average weight of each casting was 17.29 lbs. These figures are not presented with the idea of making any comparisons with production elsewhere under totally different conditions, but with the idea of suggesting the dimensions of the problem of control of quality under these circumstances.

Leaving aside the commercial aspects of the problem, it is found that, from the engineering standpoint, quantity production is made possible, first, by so sub-dividing operations that each step is made as simple as possible; secondly, by providing machines wherever possible to take the place of hand labour; and, finally, by devising a system of control and inspection which will ensure the work being turned out to predetermined standards. Of these three steps, the last is perhaps the most important, but the first two have resulted in a complete change in the way the factor of human skill enters into the problem of production. This is a matter of no little moment.

It is customary for those who take the position that modern high-speed production implies a lowering of quality standards to point out that these methods have eliminated the skilled workman and annihilated craftsmanship, without which a superior product cannot be produced. This is not true. What quantity production has done is to change the way in which craftsmanship is applied to the job. In part, under the factory system, the responsibility for quality, which is the most that craftsmanship implies, is transferred to the engineer and the trained executive, while the workman, instead of losing by this shift, is left more free to specialise and to become truly skilled within his particular sphere.

The Sub-division of Labour.

In the foundry, to meet successfully the enormous demands of a twentieth century civilisation, special methods, involving radical departures from regular, traditional, or what might be termed orthodox practices, have had to be developed and introduced. Commenting on this, Pat Dwyer, engineering editor of "The Foundry," stated: "It was realised that the human factor could not be dispensed with altogether, but it was felt that by providing suitable mechanical equipment the out-

put from each operator could be tremendously increased without the slightest deterioration in quality. Furthermore, as the scope of mechanical equipment was extended it was found that the process of making moulds could be divided into many elements, and that each of these elementary operations could be performed by a separate workman. Therefore in the United States, where formerly a period of four years was required to develop a moulder, competent to begin and finish his work, under the system now in vogue in specialty shops, ordinary labourers can be taught in a few hours to fill any missing link in the long chain of production."

This not only illustrates the flexibility of the quantity production system, but also goes to show that while moulding skill, manual dexterity, and mature judgment on the part of the workman are regarded as an important requirement in a jobbing shop, they are neither an asset nor a necessity in a specialty foundry. Power-driven devices, accurate pattern and flask equipment, and

THE METALLURGIST WATCHES THE POURING OF THE TEST-PIECE TO DETERMINE THE APPROXIMATE TEMPERATURE OF THE METAL.

mechanical appliances for handling material and making moulds, have reduced the personal element to a minimum, and have placed the manfacture of certain classes of castings on a mechanically automatic basis. And in many cases the superior precision of the machine has actually resulted in both a more uniform and a better product than could possibly be produced by the most skilled moulders and so-called old-time foundrymen.

But the necessity for a comprehensive and intimate knowledge of foundry practice is by no means eliminated under the quantity production system. It is simply transferred from the many to the few. On those who remain the repositories of skill, judgment and knowledge, the burden of responsibility is enormously increased. It is the part of these leaders to synchronise and co-ordinate the efforts of the various operators, and to set high standards and see that they are maintained. But in a large shop a few such men can direct, vitalise, and control a thousand workmen. Under this system the individual workman simply does one part of a job over and over again. Logically, he does it as well, if not better than a man who has to spread himself over many jobs. Under the quantity-production system, each operation is performed by an expert, who soon develops far more skill than the best journeyman moulder who tries to do everything. This tends strongly to an improvement in the quality of the product.

Views of Henry Ford.

Henry Ford, in a recent book, explains this phase of the problem of co-ordinating quality with quantity production in the following language:—

"I have heard it said we have taken the skill out of work. We have not. We have put a higher skill into planning, management, and tool building, and the results of this skill are enjoyed by the man who is not skilled, to his great benefit, for it is self-evident that a majority of the people in the world are not mentally, even if they are physically, capable of making a good living.

"We now have two general principles in all operations—that a man shall never have to take more than one step if it can be avoided, and that no man need ever stoop over, in the foundry or elsewhere. Furthermore, a man must not be hurried in his work—he must have every second necessary, but not a single unnecessary one. The results of these methods are visible everywhere in the Ford factories. Take the case of assembling the flywheel magneto. One workman doing the complete used to turn out 35 to 40 pieces in a 9-hour day, or about 15 minutes to an assembly. What he did alone was then spread into 29 operations. This cut down the assembly to 13 minutes. Then we raised the height of the bench at which the men work by 8 in. and cut down the time to 7 minutes. So to-day one man can do what two did."

In the United States it is felt that it is not necessary to follow slow, expensive, hand-production methods to produce a quality product. Given raw materials of the proper sort, coupled with methods which are right and an organisation which ensures the proper maintenance of standards both as regards raw materials and methods, and the result must be a satisfactory product of uniformly high quality. It is firmly believed that this is true, but it is worth repeating that underlying this whole problem is the question not of energising, but controlling, the processes of production.

(To be continued.)

New Zealand Iron Industry.—The Onakaka Iron & Steel Company has had a trial run of their blast-furnace to treat the Golden Bay deposit of iron ore. The result is declared to have been satisfactory and the Company is proceeding to erect coke ovens. Conditions are favourable, for iron ore, coal, and limestone are all near at hand and the deposits are owned by the Company.

XUM

Institution of British Foundrymen.

BIRMINGHAM BRANCH.

At the meeting held at the Municipal Technical School, Birmingham, on November 11, there was an open discussion on Cupola Receivers and Blow Holes. Mr. W. J. Flavell (Branch-President) was in the chair.

CUPOLA RECEIVERS.

Opening the discussion on cupola receivers, MR. F. J. COOK said that anyone who inquired into the question of receivers could not help but be struck by the want of data, both in proceedings of Associations and in text-books. The Proceedings of the Institution, which dealt primarily with foundry matters, he believed contained the word "receiver" only once, and then it referred to a cupola receiver, but in a very casual way. Further, although every foundryman knew what a receiver was, generally speaking there were not many who were acquainted with the fundamental features of receivers. There was, of course, the mechanical operation of the receivers, and also the chemical reactions that took place. Mr. Cook then showed a number of lantern slides illustrating different types of receivers. The first was a well-known outside receiver, which had been made by Messrs. Thwaites Brothers for a very long time. One of the principal arguments in favour of receivers was that there was a considerable saving of coke. In addition, as soon as the metal melted, it dropped away from the coke, and was not contaminated with sulphur to the same extent. Another slide showed a receiver in the body of the cupola itself. The receiver was divided from the cupola proper by means of a brick. One of the detrimental features of the receiver was the question of cold metal at the start. In this particular receiver the gases and flame went right down on to the top of the metal, and it was a distinct improvement, as it gave hot iron at the start. This could not be relied upon where the flame and gases entered at right-angles and struck first the side of the receiver. In two instances, one of which was such a cupola, but the designer did not install a pipe, as he failed to see its use. He said the cupola did very well, but it did not come up to his expectations. In the case of another cupola of this type, a proper side pipe was provided, but unfortunately the cupola man did not see the use of it, and bricked up the hole leading to it. When this was opened out, he found a very great difference in the temperature of the metal. If there was no outlet for the gases in the receiver, obviously there was pressure which retarded the flame coming down.

Dump-Treating Machines.

Some years ago he installed a machine for taking the shot and iron from the dump. Several foundries were visited and details obtained of its efficiency, and in many cases it appeared a paying proposition. When the machine was installed, a careful account was taken of the amount of metal recovered and the time taken in the process, and he found that it did not even pay for the requisite motive power. He came to the conclusion that if the slag was drawn off in a fairly fluid state, the metal ran through the slag and became a cake at the bottom, whereas if they dumped the whole, the slag was very often not so fluid as in the receiver at the end of the blow, and they did not get that settling down of the metal which they did with a receiver. When the iron was recovered in a very fine shot form and recharged into the cupola, it very often went right through the melting zone quickly without being melted, and was found as pellets in the metal. A slide was shown illustrating an ingenious arrangement, designed by Mr. J. E. Hurst, of Kilmarnock, incorporating an oil-fired receiver. This was an arrangement which seemed to him to lend itself to great possibilities. It eliminated the possibility of cold metal at the start, because the oil burners heated up the receiver to quite a high temperature before starting. The metal was tapped out in the usual way, and it need not be tapped out as it was cast. It also lent itself to the addition of different alloys, even of steel. At the present time it was acid lined, but next time it was hoped to replace by basic lining to ascertain the effect on the sulphur. The question of cost with this particular apparatus did not seem to be particularly great. The consumption of oil for the starting period was 15 gallons, and melting for five hours, 31 gallons; total, 46 gallons. That was a consumption of 2.56 gallons per ton of metal. Obviously with receivers mentioned, the saving in coke was not to be obtained with cupolas working on light castings, such as was used in the Black Country, where the tap hole remained open for the whole of the blow.

Summary.

The question of the advantages and disadvantages of receivers he considered might be summed up as follows:—The advantages were that the metal was removed from the coke as melted. It was not contaminated by lying in the coke, particularly if the coke was sulphury. Instead of the metal lying between the spaces of the coke, it all came out into the receiver, and the metal was poured over two spouts, which gave better mixing than just dropping in betwen the spaces and drawing out with one tap, and, being clear of coke, allowed the metal to free itself of slag better. It also permitted a better chance of freeing itself from manganese sulphide, being kept very hot by the flames playing on top of it. There was, of course, the saving of bed coke, which was quite an appreciable factor. Against those advantages they had the disadvantage of cold metal, due to the warming up of the receiver, and in that respect he thought a receiver inside the cupola was the most advantageous, in addition to which, there was the extra labour in connection with the fettling and looking after the receiver.

DISCUSSION.

PROFESSOR T. TURNER thought there was no doubt as to the advantage of a receiver, provided they were dealing with a fairly considerable quantity of metal and that they had time to allow the metal to remain in the receiver. Where it could be used, it gave much greater uniformity of metal, a cleaner metal, and a metal that was lower in sulphur. As to fuel consumption, he would have anticipated that it would have been a little higher. Supposing they had continuous melting, and in one case they conducted it entirely in the cupola, and in the other they had to heat up a receiver, he should assume that there would be certain heat lost, due to heat radiation, when a receiver was employed, owing to the larger space which had to be heated. Where a bed of coke could be saved, the economy might be in the other direction.

MR. COOK said he believed that the cupola without a receiver used to consume approximately 14 cwt. of fuel for the bed, whereas with the Matchell receiver it only required about 4 cwt. It must be remembered that there was not continuous working at the present time.

Syphon Brick Cupolas.

MR. A. PARSONS inquired how it was, in the case of M. Ronceray's cupola, that the moment the blast was shut off the metal stopped running. He suggested as a possible explanation that the cupola, being full of air somewhat under pressure, it naturally pressed down on the metal while the blast was on, and the moment they took off the blast that pressure was released.

Replying, MR. COOK said it was not the heat from the incandescent coke which caused melting; it was the formation of gases, causing chemical action to take place. If the blast was shut off, the gases which caused the metal to melt were also excluded. Pressure would, of course, also help the flow of metal.

MR. A. WARDLE mentioned that when engaged in melting hematite iron continuously, he very soon discovered that the connecting brick between the cupola and the receiver would not withstand it. The cupola would run possibly for six or seven hours and then the cupola necks became hot necessitating cooling with hose pipes. Much money was spent in attempting to make it a success, but eventually it was concluded that it was merely whipping a dead horse. The receiver which con-

verted it into a successful cupola was removed. Later he was connected with the installing of another receiver cupola, for a different proposition which required a very high temperature. This, too, was an absolute failure, as the first 10 cwt. of iron was useless, being intended for high-class automobile work. During the war when making aeroplane cylinders, the required standard was reached by means of the ordinary cupola.

MR. COOK said he agreed with what Mr. Wardle had pointed out. With a receiver having the hot air and flame entering at right angles, and not playing on the top of the metal, the same results could not be expected as where it came down directly on to the metal. The connecting brick was a difficulty, but it was sometimes through want of care. With a receiver inside the cupola he had had to make cylinders equally as important as those mentioned, and there was no difficulty whatever in working with an inside receiver. He should not recommend an outside receiver for automobile work. But after about ten years' experience with an inside receiver, he would have no objection to installing one as the metal was always good.

Small Receivers Useless.

MR. D. WILKINSON said he had had experience with receivers in connection with both large and small cupolas. At one foundry there was a cupola that could melt up to 10 tons an hour and a receiver of 6 or 7 tons capacity. There was a quantity of really heavy work there which required fairly cool metal, and no trouble whatever was experienced with the receiver, but a small cupola with an outside receiver was a failure. On a small cupola, where hot metal was essential, there was no coke saving. The only way in which he had been able to work a small cupola with an outside receiver was by filling the receiver with coke and fitting a tuyere at the bottom. It seemed to him that the siphon brick was quite an unnecessary addition to the cupola, and was more likely to cause trouble than benefit. The way in which he had obtained hot metal from a cupola having a deep well was by inserting a kindling tuyere. This warmed the lower part of the furnace so effectively that really hot metal came down initially.

MR. WRIGHT said Mr. Wilkinson confirmed his own experience to the advantage of a kindling tuyere. He had used such a tuyere in the cupola for quite a long time, and had found it helpful in getting the cupola started quickly, as it provided a bed so hot that the iron that came down first was not cooled by falling into only partly incandescent coke. He asked whether it was a reasonable suggestion to have a movable receiver so that the small charges could be topped out into shanks and into the receiver used for larger quantities.

MR. COOK said there were a considerable number of Matchell receivers installed, and they were invariably well spoken of. A movable receiver could be used, of course, but he could not see any reason for removing it.

Mr. Wilkinson read Mr. A. Field's paper on "Blow Holes."

BLOW HOLES.

In dealing with the problem of blow-holes in so far as they may be caused by the metal, particular attention should be paid to casting as hot as possible. Some foundrymen advocate the practice of allowing the metal to stand in the shank for a long time "to allow the gases to escape," and they then cast with metal not far removed from the pasty stage. The author advocates casting as hot as possible, and using a facing sand which will withstand the temperature, then the liability to blow-holes is much reduced. When so doing, there is opportunity for the gases to find their way to the feeding heads, risers or vents, and hence away from the casting; but in cold-cast metal, especially if low in phosphorus and silicon, no such opportunity is provided. If cold metal is sufficiently good for making castings, it is preferable to economise coke and not trouble to melt hot.

In using coke of unusually high sulphur-content, or with metal which from other causes contains a high percentage of sulphur, extreme difficulty is found in making sound, clean castings. Not all blow-holes are due to sulphur, but some undoubtedly are. Such metal, although apparently melted hot, quickly becomes sluggish, and leads to these faults. It is not uncommon in such cases to find a distinct smell of sulphur dioxide arising from the iron in the ladle, a conclusive proof that gases are being evolved.

A further cause of "gassy metal" is rusty or otherwise heavily-oxidised material. An extreme case is seen in the production of annealing pans where 50 per cent. of the cupola charge is old material, with a heavy layer of oxide. Of course, in theory, the whole of this oxide passes into the slag, but in practice there is a tremendous amount of carbon monoxide evolved by reaction within the cupola, and the slag being very heavy and thick, there is no proper chance for gases to escape. Hence one rarely, if ever, sees a reasonably sound annealing-can, and many cans have their life much shortened by their unsoundness.

Damp Ladles.

But to the author's mind, the bulk of difficulties arising from gases are due *not to the metal, but to the mould*. Perhaps as an intermediate step it should be mentioned that the ladle which conveys the iron and from which, not infrequently, masses of bubbles are seen to arise. Damp ladles, especially common with smaller sizes, lead to the evolution of steam, the volume being immense in proportion to the moisture from which it arises. This does not obtain often with large ladles where great risk is entailed by dampness, but with small ladles it is often observed.

Mould Troubles.

From the mould itself, as is well known, large masses of gas are evolved, whether from cores, green sand or dry sand. It must not be overlooked that at a red heat, both core sand and dry sand give off combined water in the form of steam; this, in addition to the steam from the water, constituting the ordinary "dampness" of the green sand. Venting is usually provided but adequate assistance is often not given for gases to escape from awkward or re-entrant corners, dead ends and the like, that it is often here that blow-holes are found. Many such cases have been dealt with, and often it is found that so-called "draws" are, in fact, blow-holes in these awkward corners which have not been sufficiently vented and form a trap or *cul-de-sac* for the gas.

Awkward Places and Hand Ramming.

Such conditions in awkward places are often aggravated by an usually hard ramming in order to make the projecting piece of sand sufficiently tough for it to adhere to the mould, and not to break away in drawing the pattern or otherwise handling the box. This hard ramming makes it still more difficult for the trapped gases to escape when actually the sand there ought to be more open to give facility for venting. Nails or chaplets used on such parts must also be tinned to prevent rust, as this also is a very frequent cause of blowing.

No attempt here has been made to go deeply into the subject or to touch theory, but only to sketch a few of the causes which have come to the author's notice.

Mr. D. Wilkinson then read his own contribution, entitled "Blowholes: Their Cause and Cure."

BLOWHOLES: Their Cause and Cure.

In the machine shop the term "blow-hole" is applied to quite a number of defects in castings. Sandholes are frequently called blow-holes, especially if the sand is embedded in the casting and is only revealed by machinery. A draw or shrinkage hole is seldom spoken of by its correct name. A fragment of enclosed slag or a bubble of trapped air are both liable to be included in the comprehensive term "blow-hole." To be quite accurate, the term should be restricted to defects caused by gases liberated either from the mould or the molten metal. One of the first essentials in the cure of any fault is a correct knowledge of its cause; so to describe as a blow-hole a fault of a totally different nature does not assist in its amelioration.

XUM

Common Causes.

Confining the subject to faults due to gases liberated either by the mould or by the metal, some causes of blow-holes need only to be mention to be dismissed. The use of overdamp sand, ramming too hard, and insufficient venting will all cause blow-holes, but in each case the remedy is obvious.

Sulphur and Blowholes.

Sulphur is frequently condemned as a prolific source of blow-holes. While not in any degree designating sulphur as a friend, the author fails to understand some of the attacks made upon it. Malleable cast iron regularly contains up to 0.4 or 0.45 per cent. sulphur, and in a somewhat lengthy experience with this material no predisposition to blow-holes has been noticed by the author. They are by no means unknown, but they could never be traced directly to the sulphur-content of the iron. Certain it is that large quantities of good, sound malleable iron contain sulphur beyond 0.4 per cent. The author is aware that he is by no means alone in the somewhat disconcerting experience of finding the sulphur-content of a cast of automobile cylinders has reached about 0.15 per cent. when, according to usual practice, it should have been under 0.07 per cent. Almost invariably it is found that castings containing this amount are as free from blow-holes as if the sulphur were normal. Experience has shown that the evil effects of sulphur are found in directions other than in the formation of blow-holes.

Dampness and Blowholes.

When a mould is being cast there is an immediate reaction between the steam, formed from the moisture in the mould, and the iron as in (i):—

$$\text{(i).}\quad 3Fe + 4H_2O = Fe_3O_4 + 4H_2.$$

The hydrogen burns at the vents and joints, forming the well-known blue flames. This reaction is endothermic, and abstracts a considerable amount of heat from the metal. The oxide formed occasionally floats on the surface, and on machining is revealed as a dirty patch on the casting. By the time the mould has filled a fair proportion of oxide will have been formed from the decomposition of the water vapour. Usually secondary reactions reduce this oxide almost as rapidly as it is formed. The reactions possible are rather complex, but to simplify matters only one will be considered. A large proportion of the molten metal is composed of carbide of iron, and this material reacts with the oxide as in (ii):—

$$\text{(ii).}\quad 4Fe_3C + Fe_3O_4 = 15Fe + 4CO.$$

To carry out this reaction completely a large amount of heat is required, so a position is reached that unless the metal is sufficiently hot to supply rapidly a considerable amount of heat, a quantity of oxide actually formed within the casting itself remains undecomposed, and floats to the top where it may be revealed on machining. If, on the other hand, the metal is sufficiently hot to supply the heat necessary for the second reaction, there is a quantity of carbon monoxide gas generated within the casting before it has set.

The case of a mould just filled with molten metal having a sufficiently high superheat to remain entirely fluid for some little time after filling the mould, the reaction between the carbide and oxide of iron will be completed, and the liberated carbon monoxide will bubble up to the surface and escape through the sand. The reaction will be completed the more rapidly, and the gas will escape the more freely on account of the high superheat. But if the metal has not a sufficient degree of superheat, a skin of frozen iron will form next to the moist, cool sand of the mould, before the reaction, slowed down by the lower degree of heat, has been completed; and the bubbles of gas, unable to pierce this skin, will remain underneath, to be revealed on machining.

As the two reactions given above take place in every mould containing moisture and molten iron, it follows that the hotter the iron is the fewer the blowholes resulting from the liberated gas, since the additional heat available speeds up the second reaction and slows down the formation of a skin of frozen metal, so allowing the gas bubbles to escape. From this line of argument it can readily be seen how imperfect melting, resulting in oxidised iron, will greatly increase trouble from blowholes by the increased amount of oxide available for reaction with the carbide, and the formation of carbon-monoxide gas. Hence blowholes due to defective melting.

Superheat Important.

According to the superheat of the metal, a casting may thus be obtained entirely free from blowholes resulting from oxide reduction, or one which, owing to the formation of a frozen skin before the reaction is completed, contains blowholes, or one which, owing to insufficient superheat completely to reduce the oxide, will contain both blowholes and oxide, forming a dirty patch in the casting.

As regards the question of blowholes resulting from occluded gases, the same line of argument applies. If the metal is cast with a fair degree of superheat, the uniform cooling and freezing permits the gases discharged from solution to escape with the gases resulting from oxide reduction. The gases retained by the iron when completely frozen, obviously do not enter into the argument, as whatever state in which they may be retained, they certainly are not retained in the completely-free state necessary to form blowholes.

The cure for blowholes may be stated thus:—Clean, hot, non-oxidising melting, and casting at a temperature sufficiently high to permit the second reaction to be completed before a skin forms and retains the carbon-monoxide gas bubbles.

DISCUSSION.

MR. J. B. JOHNSON agreed with Mr. Wilkinson that if they wished to eliminate blowholes, the higher the temperature of the metal, the better. It gave a chance for the gases to escape, and his experience was that castings were very much cleaner and better the hotter they were cast.

MR. COOK said one had to remember that hot metal would not hold occluded gases to the same extent as cold metal, and therefore it became a question of the time the metal would remain fluid. He could not quite agree with Mr. Wilkinson in saying that he did not look upon sulphur as being the friend of the foundryman. There were certain classes of work where sulphur was a very good friend to the engineer, who had to use the castings. One of the causes of badly-melted iron was trying to save coke. If they had the bed of coke too low in the cupola, oxidation would take place.

MR. WRIGHT thought the first reaction mentioned by Mr. Wilkinson accounted for some of the explosions sometimes experienced in the foundry floor. Both reactions, however, seemed to affect only the surface of the casting. Does Mr. Wilkinson suggest that blowholes in the body of the metal are caused in this way?

MR. WILKINSON agreed that the first reaction frequently accounted for explosions resulting from faulty ignition of the gases. The only risk of blowholes being retained from the second reaction was when a skin of metal formed before it took place. If the whole of the metal in the mould was perfectly fluid, and no skin had formed on the outside before the second reaction was completed, the gases had a chance of escape.

Pin Holes in Chilled Rolls.

MR. A. PARSONS said his business was making chilled rolls, and under the skin of the metal pinholes were often found. He would like to have an explanation of that, and he would also like to know the effect of rusty scrap on the mixture.

MR. WILKINSON replied that, in his opinion, the occurrence of pinholes was entirely due to the second reaction. The use of rusty scrap has the tendency to give over-oxidised iron. If oxide of iron was present in the cupola, some of it would be reduced by the carbon, but it would not all be reduced, as the length of time in which it was in contact with the carbon was not sufficient. It was the inability of the carbon monoxide to escape from the casting, due to the quick setting of the metal, which caused blowholes. The only way in which Mr. Parsons would be able to overcome his difficulty would be to prevent the chill freezing the metal the moment it touched it. This, of course, was not possible.

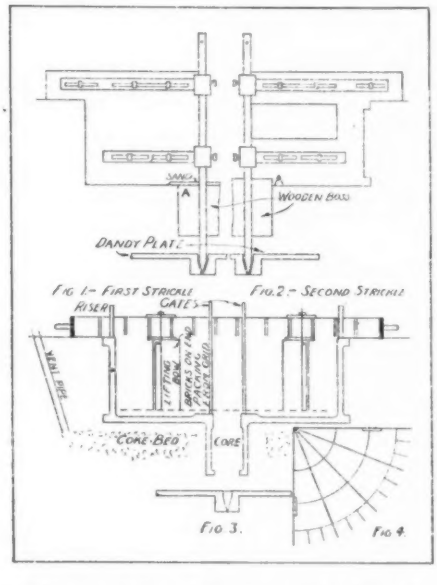
MR. H. L. REASON (President of the Institution) said it was clear from the discussion that if they were to get to the root of their troubles and

master their business they would have to enter into the question of chemical composition, not only of metal in its solid state, but also in its fluid state. He made a strong appeal to the members to undertake propaganda work, with the view of increasing the membership. It was up to all of them, he said, to take advantage of the information that was available, and make use of it in their everyday practice. They were doing serious national work, and if British foundries were to take their place as the foremost among the industrial nations of the world, they must assimilate the information and experience that was disseminated at the meetings. He thought their cordial thanks were due to those who had favoured them with such interesting contributions.

Making a Skin-Dried Clutch Mould.

By A. SUTCLIFFE, M.I.Brit.F.

It is usual to make small friction clutches in green-sand moulds from a full pattern. Larger ones are generally made in loam, but such a method is expensive, when only one or two are required. Loam moulding involves four plates, a 2½-in. bottom plate, two circular bending rings, and a 2½-in. top plate. Thus the weight of metal would be about 7 tons for a 7-ft. dia. job in plates alone. In the method proposed the grid for lifting the centre is made in skin-dried sand, which eliminates the above cost. The cost of the mould which will be described will not greatly exceed the cost of moulding the plates and melting the necessary metal when loam-moulding. Even when the tackle is made for loam moulding there is obviously the actual moulding which is expensive, as a loam



moulder requires a labourer constantly. Drying loam moulds is much more expensive than skin drying.

Skin-Dried Method Outlined.

At the pattern-making end of the business, the strickles required are practically the same in the new method as in loam moulding. It incorporates a round bush for the centre, which will fit on to the spindle and produce the part marked "A" in Fig. 1. This would also be advantageous in loam moulding. To commence moulding, a hole is dug of 4 in. less in diameter than the finished casting. It extends to 8 in. below the bottom of the centre boss ("A," Fig. 1). A dandy plate is placed centrally in the hole, and the spindle is set up, ascertaining that the socket is clean.

A cinder bed, 4 in. thick, is now prepared, and a rut is cut in the wall for the vent pipes, as shown in Fig. 4. Some moulders place a ½-in. layer of hay on the cinder bed and sprinkle it with water. The writer fails to see the advantage of this, especially in the case cited, as the bed is only about 4 in. from some parts of the face of the casting. It is, further, difficult to dry the hay by means of skin drying. The hole is now filled in with floor sand up to the boss pattern, and it is well rammed. The boss can now be bedded in and lined up with facing sand, filling in again with floor sand to the top of the boss, which must stand up to the top of the casting plate. This provides a foundation for strickling, as the depth and impression of the top box is given as is shown in Fig. 3. The whole is now rammed up to just above the depth of the strickle, but 2 in. requires cutting down from the sides, which are formed by the ordinary floor of the foundry. This is obviously very solid, and forms a good background to ram up against, and allows of a good top impression being formed.

The first strickle being finished with, the sides are lined up with wet parting-sand, and having made the grid for lifting the centre (Fig. 4), the spindle is removed and cotton waste is placed in the socket to prevent it from being filled with sand, as it is required later in the process. The mould can now be rammed up to the floor joint, taking care to place scotches from the grid to meet the box bars by the lifting bows, thus preventing the grid from slipping. The top box is placed in position, three runners are provided on the boss, and one at each side of the rim for risks. After ramming up the top part, it is taken off and turned over, as is illustrated in Fig. 3. After mending and ascertaining that the gates and risers are clear, the mould is wet-blacked and stoved overnight.

Returning to the bottom portion of the mould, the cotton waste is removed, and the spindle again replaced. The sand forming the base of the mould is cut up to about 4 in. below the top of the boss. Ample venting is given this face with a ½-in. wire cross handle. Some moulders make up these holes one at a time with an iron rod or their finger The writer, however, does not consider this to be an advisable method, but merely waste of time. It is preferable to scratch them with the fingers and place on facing sand, and then tread with the feet or lightly ram with a flat rammer.

The second strickle is cut to allow for the thickness of the plate, as is shown in Fig. 2. At the boss corner this comes to the top of the plate. The strickle will take from the sides and the bottom the thickness of metal required. The bottom of the face is needle-wired, so as to catch the ½-in. wire-vents below. It is preferable to keep the needle wire on the slant, which allows of the inclusion of many of the ½-in. vents. The centre boss is now removed, and the mould is spindle finished and wet-blacked. The mould is now skin-dried. If coke baskets have been used, clean out the ashes and insert the centre core. Parting sand is placed round the top joint to prevent a crush at the rim edge.

If the method described has been faithfully followed it should be unnecessary to try the thickness with clays. The mould is finished by making up the gates and risers, placing on an adequate quantity of weights, and cleaning the vent pipes. The mould is then ready for casting, and is shown in Fig. 3. Careful examination of the process will reveal it to be much cheaper than when made in loam.

Study of Hearth Gases from Blast Furnaces.—In the course of a study of hearth gases from blast furnaces, being made by G. St. J. Perrott, of the U.S. Bureau of Mines, at Birmingham, Alabama, the results of sampling hearth gases have so far shown no difference in the combustibility of different cokes in the hearth of four blast furnaces. There is a difference in the rate of reaction of different kinds of coke with carbon dioxide at 1,000 deg. C. These results corroborate the combustion experiments that are being carried on in the Kreisinger furnace. The suggestion has been offered that combustibility tests be made in a small furnace at the lowest possible rate at which combustion may be maintained in order to determine if there is a different influence of the various kinds of coke on the rate of combustion at low temperatures. It may be that combustibility of coke in the blast furnace is significant not at the hearth, but well up in the furnace, where the temperatures are much lower. This problem will have to be attacked by getting gas samples higher up in the furnace. It is hoped to make an arrangement with a blast-furnace plant to take samples higher up on the bosh.

XUM

Some Casting Problems of Acid-Resisting Irons.*

By John Longden, A.M.I.Brit.F.

Several well-known acid-resisting iron-silicon alloys are to-day made into castings, being recognised under such names as Duriron, Ironac, Tantiron, etc., and are especially intended for the use of manufacturing chemists.

These alloys, however, offer exceptional difficulties to the foundryman. The foundry practice which will be described here is that which is carried on in the production of castings in a high-silicon iron having a world-wide reputation. It is not thought desirable, however, that reference should be made to its trade name.

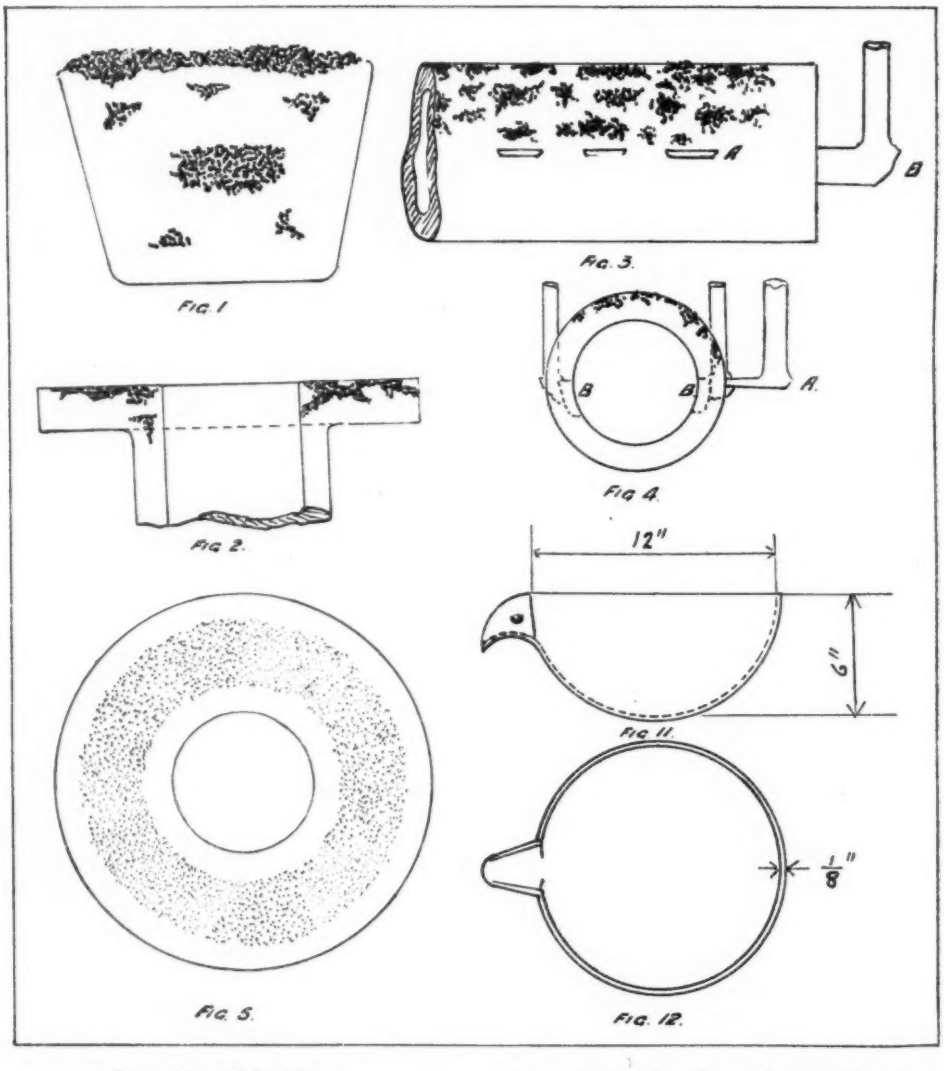


FIG. 1. FIG. 2. FIG. 3. FIG. 4. FIG. 5. FIG. 11. FIG. 12.

Composition of the Alloy.

The silicon content of the alloy, as it leaves the foundry in the form of castings, ranges between 12 per cent. and 15 per cent., depending upon the particular use for which the casting is intended. Except for special purposes, however, it is seldom above 14 per cent., above which the alloy is hardly machinable. The full analysis of the metal is usually somewhere between the following limits:—Silicon, 12 to 15 per cent.; total carbon, 0.2 to 0.6 per cent.; phosphorus, 0.16 to 0.2 per cent.; manganese, 0.25 to 0.35 per cent.; and sulphur, under 0.05 per cent. Antimony also is present in small quantities. Pieces of the metal, estimated to introduce 0.1 per cent. into the alloy, are placed in the bottom of the shank or ladle waiting to receive the alloy from the furnace, the alloy being run on to it, and the latter is soon dissolved by the flowing metal.

Physical Characteristics.

The alloy has a specific gravity of about 6.8 and a tensile strength of about 6 tons per sq. in. It melts at a temperature of about 1,200 deg. C., and contracts, after solidification, 3-16th in. to the foot.

Attention will be drawn later to the casting difficulties arising out of its relatively low tensile strength and high contraction, though, in the latter respect, the alloy under consideration compares very favourably with other alloys of a similar character.

Melting Practice.

The alloy is melted in the cupola like cast iron, though rather lighter charges are used than in the case of the latter. Before being used for castings the metal is run down and then re-melted. The raw materials used are wrought iron and steel scrap, scrap from faulty castings heads, runners, etc., of the same alloy, and ferro-silicon pig. Sometimes a little selected cast-iron scrap is used also. In calculating the charges, an allowance is made for loss of silicon of 0.5 per cent.

Two cupolas are in use, of 18 in. and 30. in. dia. respectively, inside the linings, the latter having a receiver attached which will hold some 25 cwt. of metal. In the case of the former, 1½ cwt.

* A Paper presented to the London Branch of the Institution of British Foundrymen on December 7.

charges are used, and, in the case of the latter, 3 cwt. charges. Coke and limestone are used in similar quantities to those used in cast iron melting practice.

Graphite Separation.

A very considerable difference is noticeable between the molten metal as it leaves the smaller cupola and that leaving the receiver of the larger. The metal leaves the tapping hole of the smaller cupola at a white heat. For a few inches from the hole, down the spout, the metal seems unchanged. As it travels further, however, it becomes smothered with a fluffy layer of dark matter, which travels with the metal into the waiting ladle or shank. In a very short time the metal in the ladle or shank is covered to a depth of 2 to 3 in. with the dark matter, which, when skimmed off, is found to be a mass of shining particles of graphite. The metal then may be carried to cast, say, an open sand ingot. When the shank or other vessel has reached the mould, and is placed on the floor preparatory to casting, the metal is found to be again thickly covered with graphite.

The metal is vigorously stirred, skimmed off, and poured. On completion of the casting operation the ingot is found to have another deep cover of graphitic matter. This may be drawn off with a skimmer, leaving the upper surface quite clean, and still very liquid. If this clean surface be watched, however, black patches may soon be seen upon it, coming up from below, until the surface is again nearly covered. This matter cannot again be skimmed off. On being examined later it is found to be mainly graphite. If the ingot, when cool, be broken across anywhere along its length, pockets will be found here and there full of glistening flakes of graphite. Such a section is illustrated in Fig. 1.

This factor is a frequent cause of scrap castings, the graphite separating out after entry into the mould, forming pockets in points of castings where two or more sections meet, or at upper surfaces of castings. Examples of this are illustrated in Figs. 2, 3 and 4. Castings which appear quite sound, however, may, on machining their upper surfaces have the appearance of Fig. 5, the dark points being finely distributed particles of graphite.

Receiver Metal is Blown.

The heavier castings are poured from metal melted in the larger cupola. To the bottom of the receiver of this cupola a 1-in. dia. pipe is laid, which is reduced to an aperture of $\frac{1}{8}$ in. dia. some 2 in. before reaching the bottom face of the receiver. Through this aperture, which is in the centre of the bottom of the receiver, air under pressure is blown vertically through the metal, the intention being to burn out carbon, as in converter practice. There can be no doubt that silicon is also oxidised at the same time.

Different Behaviour from Different Cupolas.

The metal from the receiver behaves in a markedly different manner from that which issues directly from the smaller cupola. No graphite covers the metal as it travels down the spout, and no graphite appears upon the top of the metal in the ladle—at least, not in the form in which it appears in the case of the metal from the smaller cupola. In this case the separation of graphite has proceeded rapidly in the receiver, the metal leaving much freed carbon behind it as it runs from the receiver. Though, however, there is a considerable difference in degree, the same kind of phenomenon is noticeable. Not much graphite of the shiny, flaky kind comes to the surface, but instead a graphitic kish appears, which very soon forms a heavy crust on the top of the metal. To get good results with the kind of castings for which the metal is used it is necessary to cast as hot as possible. The metal is therefore taken from the furnace, vigorously stirred, skimmed and poured. Though, as has been noticed, the tendency for separated graphite to appear is less in the case of the metal from the larger cupola than from the smaller having no receiver, it still remains a serious difficulty, pockets and fissures full of graphite frequently being found in castings poured therefrom.

Theoretical Desiderata.

At this point it may be worth while to examine briefly the factors which produce the effects which have been noticed above. It is generally granted, in competent quarters, that the eutectic of the iron-carbon series of alloys is reached when the alloy has a total carbon content of 4.3 per cent. This alloy freezes at about 1,130 deg. C. At the higher temperatures within the cupola, however, the metal may take into solution more than the eutectic amount of carbon. Within certain limits molten iron dissolves carbon very readily. It has been estimated that a saturated solution at 1,400 deg. C. contains about 6 per cent. carbon, though this figure may be greater at higher temperatures. As, however, the temperature of the metal falls to freezing point, the carbide in excess of the eutectic degree is precipitated, such carbide then being dissociated, iron and graphite each being liberated and kish produced.

If a third element, silicon, be added to the iron-carbon eutectic alloy, an important result follows, the solubility of carbon being materially affected. This phase has been examined by Wüst and Petersen. The results of 15 tests made by them are shown in Table I. Putting the data provided by these investigators in graphic form, a curve is produced as shown in Fig. 6.

TABLE I.—*Tests of Silicon-Carbon-Iron Alloys by Wüst & Petersen.*

Test No.	Silicon, per cent.	Total carbon, per cent.	Freezing point, Deg. cent.
1	0.13	4.29	1,138
2	0.21	4.23	1,131
3	0.66	4.05	1,156
4	1.14	3.96	1,155
5	1.41	3.88	1,160
6	2.07	3.79	1,175
7	2.68	3.56	1,185
8	3.25	3.41	1,187
9	3.69	3.32	1,197
10	3.96	3.24	1,205
11	4.86	3.08	1,210
12	5.06	2.86	1,215
13	13.54	1.94	1,123
14	18.76	1.19	1,240
15	26.93	0.87	1,255

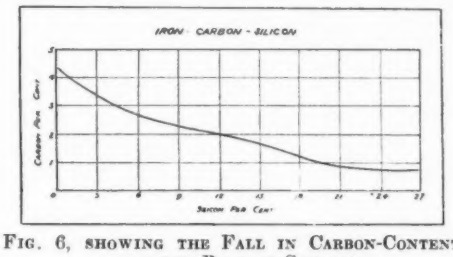


FIG. 6, SHOWING THE FALL IN CARBON-CONTENT WITH THE RISE IN SILICON.

The important points to notice in the table are (1) the regular fall in carbon content with successive increments of silicon, and (2) the equally regular rise in the freezing points.

In the course of Mr. J. E. Fletcher's illuminating Paper on "The Blast Furnace and the Foundry Cupola,"* it is demonstrated that for every 1 per cent. silicon which is introduced into cast iron, 0.286 per cent. carbon is thrown out of solution, and that for every 1 per cent. phosphorus which is introduced, 0.387 per cent. carbon is thrown out of solution at or before the moment of solidification of the metal.

The influence of manganese and sulphur upon carbon solubility in the small quantities which are present in the alloy under consideration may be regarded as negligible.

From the data provided by Wüst, Petersen and Fletcher, it would appear that an alloy containing 14 per cent. silicon and 0.2 per cent. phosphorus would have, on freezing, a total carbon content of approximately 1.6 per cent. Though, however, the carbon is low in the solidified metal, it may be, and doubtlessly is, high in the metal at temperatures well above freezing point. In the course of a series of interesting experiments which were carried out by Messrs. C. E. Williams and C. E. Sims (detailed in a Paper read before the American Chemical Society),† which were intended

* "Foundry Trade Journal," March 30, 1922.
† "Foundry Trade Journal," August 3, 1922.

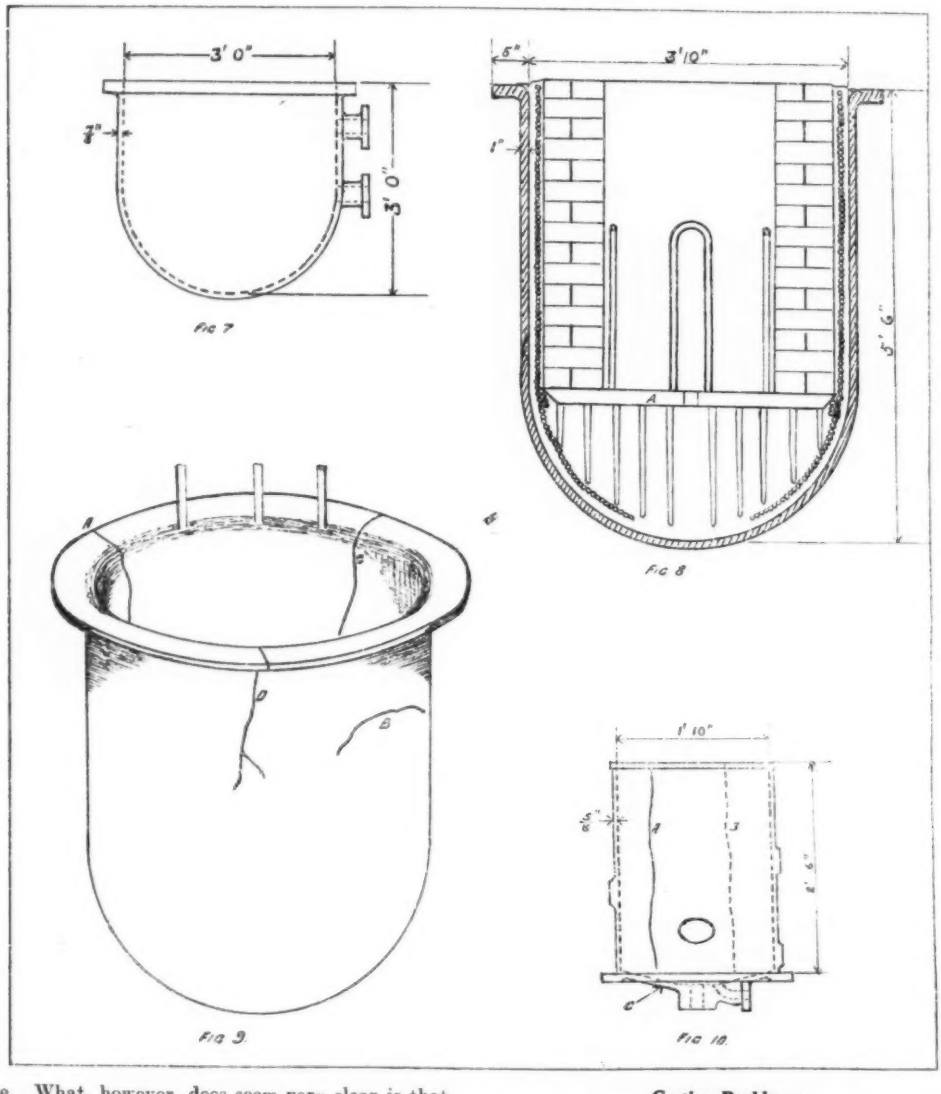
to demonstrate the effects of various elements in influencing carbon solubility in iron, the writers conclude that, though the presence of a large quantity of silicon does decrease the amount of carbon dissolved in the frozen iron, it does not affect the amount of carbon which is absorbed and held in solution by the metal whilst in a molten condition. This conclusion is in line with that reached by the present writer as a result of his observation of the behaviour of high-silicon iron.

Carbon in Liquid Iron.

In what form the carbon may be present in the molten iron is not very clear to the present writer, whether definitely as carbides or not, though authoritative opinion appears to be to the effect that, at the higher temperatures, the whole of the carbon in solution is present in the form of carbide. What, however, does seem very clear is that an iron-carbon alloy containing 14 per cent. silicon and 0.2 phosphorus may hold, whilst molten and at the higher temperatures, a very considerable quantity of carbon, the excess of which, with falling temperatures, continues to separate out, right down to the moment of solidification. This, therefore, explains the presence of large quantities of graphitic kish which appears on the surface of molten high-silicon iron which has been melted in the cupola. It also explains the presence of pockets of free graphite in the castings made from the alloy, the separation continuing in the metal after entry into the mould, the kish floating to the surface or being trapped and held at other points.

Types of Castings.

Of many types of casting which are made in this alloy, including, amongst others, autoclaves, pipes, valves, cocks, pumps, pans and stills of various sizes and design, it may be said that the making of many of them present little difficulty to the foundryman other than that due to the separation of free graphite. The principal type of casting made, however, is a liquid-holding vessel of some shape or other. A casting of the shape and design of the circular pan shown in Fig. 7 presents little or no difficulty. It will be noticed that the top flange is relatively narrow and thick, whilst the diameter of the pan is equal to the depth. A good number of castings of this type have been made, some of considerably larger and some of smaller dimensions than those given in the illustration, without trouble—other than that due to kish formation. The castings are made in loam, and run from the top through three or four small rectangular sectioned runners.



Casting Problems.

Another pan, however, which gave trouble to the writer is shown in Figs. 8 and 9. The weight of the casting was about 23 cwt., the internal diameter being 3 ft. 10 ins., and the depth 5 ft. 6 ins. It is now an accepted principle among chemical manufacturers that the pans which they use shall be cast in the same position as that in which they will sit in use, *i.e.*, open end upwards. Fig. 8 shows the casting in section, with the construction of the core. The outside part of the mould calls for no comment, being built up in the ordinary way. In building up the core, however, four stripping bars, triangular in section (not shown in the sketch) and being the full length of the straight part of the core, were placed upon the top-plate, dividing the circumference of the core equally, and standing back 1½ ins. from the

strickle; a narrow edge of the bar being nearest the casting face. A 9-in. brick-wall was built up between the stripping bars, leaving the centre of the core hollow. On the top of this building was put the crown plate A (Fig. 8) carrying prods, the spaces between which were filled up with bricks and loam in the ordinary way. Before the loam was put on the building, hay-rope was wound round the core from the base (as moulded) to near the crown, a double line of rope being wound round the outer edge of the crown plate. The core was then struck up with the strickle.

After the core was dried and finished, hook-bolts were attached to the staples in the crown plate and pulled firmly up to the top-plate. Three runners were placed as shown in Fig. 9.

The mould was assembled and cast with metal, which would be described by most foundrymen as fairly hot. Twenty-five minutes after casting, the top-plate was taken off, the stripping-bars were pulled out, and six men, in relays of three, proceeded to dig out the brickwork down to the crown plate so that the latter could be lifted out. Just before the crown plate was lifted out, however, a crack was observed in the casting at the point A in Fig. 9, which soon spread across the flange and then down the casting for about 15 in. The casting was scrap.

Such a casting, if made in cast iron, would present no difficulty. The casting could have been left until cool before getting out. Nothing need be feared from the pull of the casting on the core. In fact, an outer pan in cast iron was made afterwards, being 3 in. greater in diameter, which was used to form a steam jacket for the inner pan, the making of which is described above. The same tackle was used, and the core was not touched until the casting was taken out some 48 hours after casting.

Diagnosis of Trouble.

In the case of the cracked pan, the difficulty was diagnosed by the writer as follows:—

When the top-plate was lifted off, a large part of the area of the top flange of the casting was bared, and, though the flange was at once covered with sand, the rate of cooling of the flange was greatly accelerated. The next step was the taking out of the stripping bars, followed by the removal of the brickwork from the core, down to the crown plate. This was rather a lengthy process, owing to the heat given off by the casting, the fumes, and the difficulty of getting out the bricks and other débris. Long chisel bars and scopes with long handles were used for this purpose. By the time, however, that the men had cleared out the bulk of the core, the top flange was getting black, the body of the casting below the flange remaining red. The flange began to contract strongly, whilst the body of the pan resisted, with the result that a vertical fissure started at the outer edge of the flange, proceeded across its width, and then straight down the body of the pan.

New Method Tried.

A second mould was made in the same way, except that provision was made for five runners instead of three. A different course was adopted in stripping the casting. As soon as the top-plate was lifted off, a good layer of warm sand was placed over the hot flange of the casting. A heavy, flat, cast-iron building-ring was then dropped upon the sand, overhanging both the outer and inner edges of the flange of the casting. The digging out of the core was then proceeded with as before. The idea behind this proceeding was that the top flange should be kept as hot as possible, so that cooling should be as even as possible throughout the casting. On examining the casting on the following day the flange was found intact. To the writer's dismay, however, a crack some 9 in. long was found going horizontally round the body of the pan, about 16 in. below the flange, as shown at B, Fig. 9. On examining the cracked part of the casting after it had been broken up, it was obvious that a film of graphitic kish, which had formed on the top of the rising metal at that place, had been held at the point of the crack. The clear metal had then risen over the ends of the film of kish, flowed over its length, and the filling of the mould then went on until complete. When the casting began to contract, however, a fissure would manifest itself at the line of the kish film.

Experiment Continued.

A third casting was made. Unfortunately the building ring, which had, on the last occasion, been used for the purpose of covering down the hot flange of the casting, had, in the meantime, been used in the construction of another mould which was of an urgent character. Instead, a light ring was placed over the flange. This was not sufficient, the casting cracking, from the flange downwards, in three places, at A, B and C in Fig. 9. When this casting was broken up, however, it was found that the cracks had started at points where kish had gathered.

Success Achieved.

A fourth casting was made, the heavy building ring again being requisitioned; a sound casting resulting.

It may be said, in criticism of this far from happy history, that it ought not to have been difficult to make tackle for the job which would have made it a simple matter to clear out the core without removing the top-plate from the casting. With that the writer would agree; but he would point out that the tackle for the job had already been made, prior to his appointment in the service of the firm concerned, and that by a competent loam-moulder who had been employed for many years at the same shop, making that class of casting. Further, it is seldom that two pans of the same dimensions are required. To make satisfactory tackle for such a job would be rather expensive, and, very probably, such tackle would not be found suitable for another job. Much progress might be made with this class of work if the castings were standardised as to dimensions. As it is, nearly every user of such vessels asks for a casting of a shape and of dimensions suitable only to his own peculiar needs. Looking back on the history of this job, one might admit that the immediately more expensive way might have been the cheaper—but these things have to be learnt by experience.

Details of Other Castings.

Another casting, a still, which proved rather difficult, is shown in Fig. 10. For casting in high-silicon iron, the walls of the casting were rather thin, viz., $\frac{5}{8}$ in.

The mould was made in loam, and cast, in the position shown in the sketch, through a number of small drop runners placed all round the top. After casting, the top-plate was lifted off and the core dug out. On the following morning, however, it was found that the casting was cracked from top to bottom, on opposite sides, as shown at A and B, Fig. 10. Another casting was made in the same way, but with the walls thickened to $\frac{7}{8}$ in., and with the top rim made heavier. When this casting was taken out, it was found to be sound round the sides, though the top rim was weakened and disfigured by deposits of graphitic kish. Further examination, however, showed that the casting was cracked round the boss at C, shown in Fig. 10. In the next mould, the core in the boss was chambered, and the weight of metal about the little branch pipe beside it reduced, with the result that the casting was successful.

Peculiarities Exhibited.

A peculiarity of the metal was shown when making a 6-in. pipe, 5 ft. long, a section of which is shown in Figs. 3 and 4. In the first one, the runner was put on the joint, as at A. It will not be denied that, in cast iron, pipes of this size may be cast successfully whilst run nearly anywhere—on the top of the flange, on the top of the pipe, on the joint, or in at the end. In this case, however, it was found that, when run on the point, the fact that the metal dashed against the core resulted in the production of more graphitic kish than usual, the top of the casting in the region of the runners presenting an unsightly appearance, being pitted with holes, which were full of shining graphitic flakes. So much was this so that the casting was useless. Another casting, which was run straight in at the end, as shown at B, Figs. 3 and 4, was quite sound, the easier flow apparently resulting in less separation of graphite. The reason for this is not very clear. It may be reasonably assumed, however, that as the metal falls in temperature, and carbon goes out of solution, much of it may remain mechanically mixed in the metal (an instance in which this was

perceptible to the naked eye is illustrated in Fig. 5) if not unduly agitated, but that, when violently disturbed, as when dashing against the core, the already precipitated graphite is more readily freed from its immediate surroundings, and floats to the surface of the metal.

Cascade Basins Give Trouble.

Another casting which is difficult to make is shown in Figs. 11 and 12. This is a small cascade basin, having an internal diameter at the top of 12 in. and a depth of 6 in. The thickness of the metal was ¼ in. This, like the other vessels discussed, must be cast hollow side upwards, necessitating the use of lifters to carry the inverted dome of sand. The only way the castings could be run was by means of six runners being placed on one side of the top rim, which dropped the metal right down the thickness. In order to prevent the moulds from scabbing, they were skin-dried. A few minutes after the casting operation the top part was lifted off. If this was left a moment too long the castings were cracked. If the mould was dried too deeply, it could not be separated sufficiently quickly from the casting. If they were not dried, or insufficiently dried, the casting was scabbed. To cut a long and painful story short, the losses due to scabbed, faint-run or cracked castings was so great that to continue to make them was impracticable. Resort was made to patterns having a thickness of 3/16 in., which were made quite successfully.

Definite Conclusions Drawn.

Arising out of the experiences related above, the writer ventures to draw certain conclusions. In the first place, it would appear to be imperative, if the making of castings in acid-resisting iron is to be put on a sound basis, that means should be found for freeing the metal of kish before entry into the mould. As carried on in the practice detailed above, the kish cannot be eliminated by any amount of shaking and skimming; at any rate, not at the temperature at which it is necessary to pour the casting. As has been shown, the graphite continues to separate whilst entering the mould, and after entry. Kish is not only a danger when it appears on the surface of the casting. The writer has been impressed by the fact that, in very many of the cases of cracked castings, the starting point has been a place which has been weakened by an accumulation of kish. It is fairly certain, further, that many apparently sound castings contain, somewhere in or about, hidden pockets of kish. Such castings may easily break down in work.

The cupola is a very good place in which to melt cast iron, but it is certainly not so desirable a means for the melting of high-silicon, acid-resisting iron. It appears to be clear that the really essential elements are iron and silicon. Therefore the alloy should be made from materials which are almost carbon free, and melted out of contact with that element, or in such circumstances as would make possible the control of the carbon content, to ensure the presence of no more carbon than could be held in solution by the metal at the moment of solidification. The electric furnace would appear to offer the means of achieving this.

More thought should be devoted to the design of castings in this alloy. Broad flanges should be avoided. They should be as narrow as possible, and relatively thick. Greater care is needed than in the case of cast iron to secure even thickness of sections, owing to its greater contraction and lower tensile strength. The chemical manufacturers who make use of castings in the alloy should reach some agreement with a view to standardisation of sizes and shape of pans and stills. The tendency to make pans deeper in relation to their width should be avoided, as this seems to make successful castings more difficult.

General Conclusions.

In conclusion, the writer is convinced that, these conditions provided, castings could be made subject to no more risk than that which is experienced in the making of castings in cast iron. The alloy itself is considerably more expensive than cast iron. On the other hand, the alloy's power of resistance to the action of certain acids has been estimated to be 1,000 times as great as that of cast iron, which should mean that the high-silicon iron casting, for certain purposes, will have 1,000 times the working life of an iron casting of similar dimensions. Therefore the additional cost is more than justified; and steps made to perfect the manufacture of vessels in this or similar alloys should be much to the advantage of the chemical manufacturing industry, as well as to that section of the ironfounding industry which specialises in this class of castings.

Working Slags.

MR. J. E. FLETCHER introduced a Paper recently read before the Birmingham Metallurgical Society by the remark that the old idea that slags in both ferrous and non-ferrous processes were simple by-products functioning as cleansing fluxes or fluxes for preventing oxidation was entirely misleading. Modern research has proved, he said, that the working slags play a much more important part. They are as indispensable in the production of the finished metal as is air in the life of the human being. It is by the control of the composition, both chemical and physical, and of its temperature that a liquid slag may supply the oxygen necessary for converting a bath of crude cast iron into excellent steel or bring it into the condition suitable for puddling, whereby a spongy ball of nearly pure iron is produced. Or again, the working slag may be supersaturated with such alloying metals as will pass into the liquid metal and produce, in the blast furnace for example, pig-iron alloyed with pre-arranged quantities of silicon, phosphorus and manganese, or produce in steel furnaces alloy steels.

The author then outlined the functions fulfilled by the slag in the blast furnace, the cupola, the Bessemer converter and the basic and acid open-hearth furnace; the changes in the composition of slag were shown in typical charges, and the influence of viscosity on the speed of reactions described. The chief point emphasised was the important tendency for liquid ferrous working slags, under conditions of high superheating beyond their melting points, to arrive at a stable equilibrium when the acid and basic oxygen contents of the slag were exactly balanced. When this point was reached the alloying or oxidising actions ceased, and could only be altered again by metallic oxide additions which destroyed the inertness of the slag. The progress of slags towards this inert condition was graphically shown by diagrams indicating the changes in the slag composition during typical heats in the blast furnace, and in iron refining, puddling and steel-melting processes. The difficulty of understanding the slag function by means of analyses of cold slag was pointed out, and the necessity for correctly deduced compositions of the slags emphasised.

From analogous researches in the domain of igneous rocks and refractories the author indicated the likely oxide combinations in the slags of ferrous processes when such slags were heated beyond certain temperatures corresponding with the change from the meta-stable to the stable condition or *vice versa* when the slags were cooled, in which condition only they were capable of being microscopically examined and their physical constituency determined.

THE SYDNEY (N.S.W.) CITY COUNCIL has reversed its previous decision and has awarded the contract for the supply of meters to the Electricity Meter Manufacturing Company, of Sydney, the price being £42,906. A previous message reported that the Electricity Committee recommended the acceptance of a tender made by Noyes Brothers for the supply of 25,000 English meters at a cost of £42,936.

A "TRADE BAROMETER" is to be prepared for the guidance of manufacturers and traders. It will take the form of a statistical service for business men, and is to be produced under the auspices of the Economics Department of Cambridge University and of the London School of Economics. The aim of this service is twofold—first, to assist manufacturers in forecasting the trend of business in the near future; and, second, to undertake from time to time researches on specific subjects, such as the volume and movements of foreign trade, stocks of commodities, the position of freights and shipping, etc.

Gating, Feeding and Casting.*

By E. Longden, A.M.I.Brit.F.

Much controversy has, during the last few months, centred around the possibility of producing castings without feeding heads. Monsieur Ronceray is responsible for the strong limelight which has been directed on the whole question of producing sound castings by slow pouring. His theories are far from being new. Slow running has been practised for very many years, but only in very special cases, some of which will be referred to later.

At the outset, it should be stated that equally successful results can be more easily and economically obtained, in the majority of cases, by pouring quickly. In so doing success lies in admitting metal to a mould in such a way that the temperature of the molten mass is as uniform throughout the mould as can be obtained.

The contentious nature of the Paper is realised, but it should be pointed out that in the examples to be shown exceptionally good results have been obtained.

Grey cast iron will, in the main, be the material discussed, and, as the properties of the metal must be kept in mind, it is proposed to survey some of its peculiarities and the effect of various elements in reducing or increasing fluidity, because this property is so very important.

Fluidity.

Fluidity is the property the metal has of flowing easily, thereby filling completely the interstices and parts of the mould. The principal factors which govern the fluidity of molten cast iron are: Degrees or amount of superheat above melting temperature as the metal leaves the cupola; available freezing point as determined by composition. A metal must be superheated considerably to get good, clean fluid iron.

The amount of combined carbon governs the melting temperature, and higher the total carbon, the longer the period of cooling. As is well known, the life or superheat of grey iron is much greater than either white iron or steel. A white iron contains a large quantity of combined carbon and only traces of precipitated carbon. In soft grey iron the bulk of the carbon is in the graphitic state. Since the combined carbon determines the melting temperature, white iron will melt more readily than grey iron. Fortunately for the usefulness of grey cast iron, the graphitic carbon must be first dissolved before the melting point is reached, resulting in a considerable amount of heat being rendered latent, which is equal to a superheating of from 260 to 280 deg. C. The melting temperature of grey iron is about 1,250 deg. C., and white iron about 1,120 deg. C.; therefore, molten grey iron possesses much more life. Silicon reduces the stability of iron carbide, and during cooling compels the carbon to precipitate or separate from combination; in so doing heat is given out and the life or fluidity of the metal prolonged. Grey iron, therefore, freezes at a much lower temperature than its melting point.

Phosphorus increases fluidity to a considerable extent. Phosphorus eutectic becomes fluid at 950 deg. C., and if the structure of the metal is sufficiently close to prevent undue segregation, it imparts superheat to the whole of the metal.

Sulphur, by favouring retention of combined carbon, reduces fluidity.

Manganese may or may not help the fluidity. Its action in forming manganese carbide tends to harden the metal, but the decrease in fluidity is not marked. By its affinity and readiness to combine with sulphur, etc., it may be said to increase the fluidity.

Aluminium precipitates carbon, combines readily with oxygen, and thus increases fluidity.

Titanium removes oxygen, and magnesium, dissolving very easily in cast iron, also favours fluidity.

Dissolved Gases.

Recent investigation has proved that much of our defective casting trouble is due to dissolved gases. Those elements which favour the removal of the gases, principally oxygen, without in place imparting some deleterious effect, will, in the future, be more extensively used. The gases occluded are mainly carbon monoxide and hydrogen. Oxygen unites with the carbon in the metal-producing carbon monoxide, possibly producing most of the gas holes disclosed after machining a casting.

Oxidised iron flows sluggishly and congeals comparatively quickly, thus preventing adequate feeding of the casting. Quite distinct shrink holes often result, and are usually found in the proximity of the gates. Very often the defect is shown immediately the runner or riser gate is broken. Some authorities on metals claim that oxygen strengthens the metal, but it seems quite clear that it is associated with hardness, higher shrinkage and gas holes. Gases will ascend by way of the fluid centre of the metal, so that, if the metal be sluggish, a considerable amount of the gases might be trapped, to be disclosed when machining. It is supposed that the feeding process is necessary to replace gas displaced as the crystals grow. But all metals, with one or two exceptions, shrink, independently of gas. Even grey cast iron is not an exception, in spite of the compensating effect of the precipitation and growth of graphite. Low carbon-content will give rapid freezing and increase the danger of locked gases.

In the softer grades of iron little trouble is encountered from trapped gases when compared with the hard cylinder variety.

Introduction of steel into grey-iron mixtures compels special attention to the necessity of obtaining plenty of superheat and rapid pouring facilities.

Metallic oxide is a source of great trouble in both ferrous and non-ferrous castings. Iron oxide very often causes shots, gas pockets, pin holes, interior shrinkage, imperfect filling of the mould, cold shuts and local hardness. The two latter faults are caused by an imperfect amalgamation of two separate streams of metal when meeting. In spite of high temperature and high phosphorus, such trouble is encountered when iron oxide is present in considerable quantities.

The last metal from the cupola is often oxidised, rendering it unfit for work of great importance.

A low melting temperature tends, in addition to oxidising the metal, to hold slag in suspension. Slag thus entrained may find its way into the casting. Gases very often attach themselves to the first solid material encountered, and are sometimes associated with suspended slag.

Temperature and Colour.

In the grey-iron foundry the pyrometer is little used. Temperature is judged by colour. Care must be exercised in judging metal by colour. A milky-white low-silicon iron may have a lower temperature than a dull-red high-silicon iron. Generally, the colours are spoken of as, in white irons, from red to milky-white and in grey iron from orange to light yellow. When viewed in the ladle, grey iron does not present quite so smooth a surface as white iron.

About 20 per cent. of the heat present in well-melted grey iron must be dissipated before setting, which means a drop in temperature of somewhere about 150 deg. C. White iron must only get rid of 75 deg. C.

Teeming Temperatures.

Careful control of pouring temperature to suit the type of mould, dry or green sand, and class of casting is very desirable. It is true to say that each distinct casting has its own correct teeming temperature. In light and heavy high-class work, such as cylinders, liners, pistons, etc., metal should be poured white hot, care being taken not to cast until any boiling which might be present in the metal, due to an excessively high temperature of melting, be stilled. To refer to extreme cases, one would not think of casting a heavy hammer-block or flywheel with white-hot metal or a motor-car cylinder with dull iron. Mass can be run stiffly.

* A Paper presented before the East Midlands Branch of the Institute of British Foundrymen.

What Happens when Iron Cools.

There are three stages in the cooling of molten iron—liquid stage, solidifying stage and solid stage. Shrinkage takes place from liquid to solid. Contraction should be termed as a decrease in volume from the solid to normal temperatures. Most foundrymen's energies are directed in trying to obtain the combination of good liquid shrinkage and free escape of gases.

A great amount of interest is aroused in locating gates. Nothing in a moulder's work requires more consideration. Temperature and the way in which metal is admitted to the mould determines either a waster or good casting. Would it be exaggerating to state that one-third of all castings scrapped are due to incorrect pouring, gating or feeding?

Molten metal, on entering the mould, gives up heat to the surrounding sand, and the greater the distance it travels, the greater the cooling effect on the metal. One can imagine the journey of the metal through a mould of some size. In some parts eddy currents will be produced, in other places it will become stationary, whilst in other parts a more rapid filling takes place. It is evident that it will be impossible for some parts to be "freshened up" with clean hot metal. These variations result in unequal times of setting, apart from the question of thickness.

Runners and Risers.

There are various types of runner-basins, runner-gates and risers. The runner-gates, which are quite familiar and about which little need be said, might be included under the terms "drop," "cut," "worm," "skim" and "fountain" gates.

Choice of runners should be determined according to location, capacity for distribution, and filling the mould with metal at as nearly as possible uniform temperature, and the subsequent effect on shrinkage and distortion. The size, shape and position of channels by which metal enters a mould must be the first consideration. Although much can be foreseen, it sometimes happens that size, number and position of gates can only be determined by experiment.

Moulders usually look for a heavy section, through which to admit the metal. Very often this is a great mistake. He may succeed in distributing the metal quickly and save a scabbed casting, but it is obtained at the expense of producing drawn places in sections already overburdened with heat. Success in making steel castings is more easily achieved by observing this fact. Possibly a casting need not be fed if due care is taken in placing the runner.

Top and Bottom Running.

Both top and bottom pouring methods are in turn praised by respective advocates as being the correct way to run certain castings. Bottom pouring is the safest when working in green sand, but even then not always the best. In all dry-sand work of cylindrical form, which must be machined, the best castings are produced by top pouring through a series of round or elliptical pencil-like gates. The metal is kept agitated, which prevents dirt or gases sticking to the sides of the mould and core, at the same time allowing a uniform shrinkage to take place. Often the best results are obtained by a combination of top and bottom pouring, as in the case of various cylinders, for gas, oil and steam engines. These are filled in by a bottom-runner until metal rises past awkward and projecting portions of the mould and cores, and then flushed with the top gates. With top pouring, consideration must be given to the effect of the blow delivered by the metal when it strikes the mould. If a little metal is first admitted by way of a bottom runner, a cushion is formed to receive the bulk of metal from the top runners. Gas cavities are formed by using bottom runners only. Shots and buttons may be formed by using top gates alone.

Dirt will not collect around in-gates if constructed and located correctly. Dirt and gases are often found far away from the runner entrance. Near the runner it will be found to be dirty if flow of metal is impeded. Sometimes a piece is cut out of mould at the place where the dirty accumulation occurs. Sponginess above and about a runner is due to excessive heat generated at one spot.

The amount of metal delivered is determined by the orifice. Obstruction, friction and change of direction tend to reduce the amount of metal delivered. Round gits of same area as rectangular ones will run more quickly, because there is less surface area. Runners, if too small, will choke if metal is not hot.

The velocity of the metal at mould entrance is reduced when using horn and skim gates. Both are efficacious in certain cases. When admitting metal at a tangent, the swirling motion tends to gather the scum in centre and top. Very good results can be obtained by arranging a number of small gates instead of one gate with same area. It is preferable to break up the gates wherever possible.

Pouring Speeds.

There are times when a mould needs to be filled slowly, and at others quickly. Rapid pouring necessitates good venting. With rapid pouring, a greater shock is delivered on the top part of the mould at the moment when filled. It would be disastrous to pour slowly a mould with large surface area; unless the top part was protected somewhat by cores, it would draw in, due to this part of the mould being subjected to a prolonged and fierce temperature. Slow pouring is necessary when a mould contains thin, dry or green-sand cores; more time is thus given for escape of gases, but the metal must be hot.

Test-bars, whether attached or unattached to castings, should be so placed that no more metal is poured through them than necessary. It is advisable to keep the test-bar mould as cool as possible and to run horizontal to get good results.

Runner gates in heavy and medium work, and also more rarely in small work, are often made in dry-sand cores.

When not desiring to go to the trouble and expense of a dry-sand mould, pieces of dried core are placed opposite and about the in-gate, especially if there is the necessity for a thin, narrow runner with its cutting action. Wire nails are sometimes stretched across the metal channel to break up the stream, so that scum may be collected in a knob formed in the upper part of the in-gate.

Riser Gates and Feeding Heads.

It is quite evident that iron, on setting, shrinks, and in many cases feeding or pumping is resorted to. This is so, in spite of the compensating effect obtained when carbon is thrown out of solution by the action of silicon. A soft grey iron contains the great bulk of its carbon-content in the graphitic state; such an iron requires less feeding in heavy sections when compared with a harder variety, unless the metal is overburdened with phosphorus, with the consequent danger from the phosphorus eutectic.

Shrinkage is a term used to describe the reduction in volume which takes place when a metal congeals from the fluid. This shrinkage gives rise to cavities or porous places in the heavy-sectioned part of the structure; it indicates an insufficient feeding of metal during setting. Cast iron is not homogeneous, and it might be true to say that there are no absolutely quite sound castings.

To supply the additional metal consequent on fluid shrinkage, feeding is resorted to, using an iron rod, pumping metal through the riser gates, mainly, and runner gates. Sometimes the runners and risers are subjected to a pumping movement, not using the rod, the object being to keep the metal moving on the top side of the mould, thereby preventing it solidifying before the mass below. Occasionally the gates are neither pumped nor rod-fed, hot metal being poured into them from time to time. In certain cases this method is preferred rather than risk the danger of the casting being spoiled, due to excessive use of the feeding rod. When feeding a heavy section with a rod hot metal must be supplied from time to time after taking out the stiffened iron in the riser bush. In the case of certain heavy castings, which are fed over a prolonged period, a reserve number of loose riser-bushes are made. After a period, and when the metal in the riser head congeals from the outside, thereby restricting the movement and feeding by the rod, the whole bush, with its solidifying and solid metal, is torn off, and a new bush substituted which is filled with hot metal.

(To be continued.)

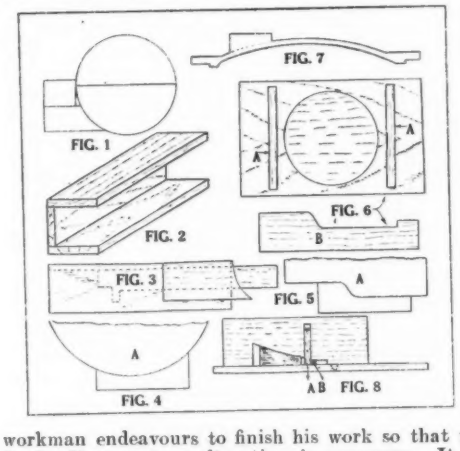
An Apprenticeship Course in Foundry Practice.—XXI.

By Ben Shaw and James Edgar.

BUILDING PATTERNS. EXAMPLES OF DIFFERENT TYPES.

When jointing the various parts of a pattern to the main body, it is not sufficient merely to aim for accuracy in measurement, but due consideration must be given to the handling the pattern will have to undergo when it reaches the foundry. Some craftsmen are very efficient at building pattern bodies, either by the segmental or staving methods, but they are failures at assembling the various parts together. The fitting of a branch to a circular body is not a difficult operation, but one man, by exercising judgment with good methods, will do it in a fraction of the time taken by another.

When the main body of a pattern is finished, either at the bench or in the lathe, the first operation, before any assembling is started, should be the marking off of centre lines for branches, bosses, and ribs. Too much care cannot be taken in doing this, because, where there are several branches at different angles from each other, a slight inaccuracy of one may cause a mistake to be made in the machine shop, which may spoil the casting. Some pattern-makers are comparatively careless in building work, and rely on the checker discovering any serious mistake, but the skilled



workman endeavours to finish his work so that no final adjustment or alteration is necessary. It is always possible to get centre lines on patterns, and in this respect the surface gauge is often invaluable. An irregular-shaped pattern may frequently be supported on a flat board, while the surface gauge is used for marking centres. With other patterns, hermaphrodites or "jennys" used from the backs of flanges serve the same purpose, while difficulties are sometimes overcome by means of a template and a "doctor," or a box square may be profitably used. The long toothed-gauge is another tool that is invaluable for making centre lines or branch joint lines that are parallel with the main pattern centre. We have already discussed drawbacks or false-cores at considerable length from the moulder's point of view, and the pattern-maker's point of view is not essentially different. Whenever it is practicable, the pattern-maker should define the moulder's joint. In what may be termed regular-shaped patterns this is a simple matter, but in many other cases it is not so. For repetition work, the first cost is of less importance, and, with small work especially, the moulders' joint can usually be defined when constructing the pattern. With some patterns it is possible to indicate the joint, and, in other cases, such as with pipes and certain valves, while the body of the pattern may not be jointed, flanges and prints are jointed, a practice which assists the moulder very materially. If often happens that branch centre lines are not on the same plane as the main pattern centre lines, but parallel to it, and it is really more difficult to fit a solid branch, and much more inconvenient for the moulder. Even when the branch is in halves, the half which is loose must be jointed to the main body, so that it will withdraw freely from the sand; it may be cut square and a small part fastened permanently (Fig. 1.). When fitting branches and bosses, some craftsmen are satisfied with a three-point contact, while others carve until they get a solid bearing. For work that is very urgently required, and which will only be used once or twice, a three-point contact may be quite satisfactory, but it is not for first-class work. As a general rule, branches that are imperfectly fitted are easily shifted from the correct position. With large branches, however, it is quite good practice to undercut the centre and make a bearing edge about ½ in. wide, which can be quickly fitted and yet keep the branches quite rigid. Chalk and colouring is far too much used when building patterns. It is nearly always possible to get a fitting outline within an ⅛ in. or less of the finished measurement, and any "marking" should only be used to ensure a bearance over the entire surface.

Fitting Branches.

When fitting branches, a knowledge of geometrical projection—a subject that will be dealt with in a future article—is invaluable. But it should not be made a fetish of, and the apprentice, while knowing how to get "points," should always endeavour to devise jigs and templates that will serve the same purpose. The commonest fitting for a branch is at right-angles to the centre line of the main body, and the simplest method of doing it is to use a box similar to Fig. 2. This consists of a channel section structure of 1-in. timber, and every pattern-maker who does much valve or pipe work should make two or three to accommodate large, medium-sized, and small branches. The branch is screwed to the vertical side A, then a template sprigged on the top, after which the fitting outline can be cut at the bandsaw with very little bench-work necessary. Fig. 3 shows the jig ready for cutting. Branches that are at an angle to the main body centre can also be readily sawn on this jig, the work being screwed on the vertical face at the correct angle.

While the above method is very usual when fitting a branch on a plain cylinder, it is only useful for roughing down when the pattern body is of several diameters, and it is also limited in its application when a fitting tongue is being cut from the solid branch. In the latter case the tongue should first be made perfectly parallel, and cut to the same width as the recess in the body, after which the jointing must be done with the pattern joint upwards. When no tongue is fitted, the most accurate butt-joint can be made by fixing the body pattern to the drawing-board and bedding the branch against it until the face of the flange is the required distance from the main centre line. In the case of a branch, the centre line of which is below the main centre line, the same procedure can be adopted, but a pad piece corresponding in thickness to the distance between the two centres must be screwed to the drawing-board.

Fitting Bosses.

For the fitting of bosses, much that has been said above is applicable. Unless they are on the pattern-joint, however, it is good practice to fit them larger than the required diameter, and saw them to shape afterwards. It may even be wise practice to plane the face of a boss and draw the shape when screwed in position. Fitting may, however, often be obviated altogether, for bosses and for branches also, where they are short and have not been turned with flange and print. The method is worth describing, because there is a big variety of work for which it is effective. Let us suppose, for instance, that at Fig. 4 we have a large diameter body A, with a boss B fitting to it. This boss B might be circular, oval, or rectangular. If rectangular, the shape should be drawn on the ends and planed or gouged through. If circular or elliptical, the block might, in the first place, be made square and fitted, after which it could be

sawn to shape. If, however, the body is of two diameters, as in Fig. 5, fitting the branch becomes a more difficult operation, and the quickest and most satisfactory way of doing it is by means of a rig similar to Fig. 6, the guides AA being shaped to the cylinder diameters, while a template with a check-piece defines the shape, which is cut with gouges. Branches and bosses of almost any shape can be fitted in this way. For a domed shape, whilst the principle is the same, the rig necessary is somewhat different. Fig. 7 is a very common saucer-shaped condenser-door. The manhole A, if fitted direct, constitutes an awkward job. It is quite possible—indeed, it is not very difficult—to get a series of points which, with the aid of a "doctor"—steel spring—to make a line representing the fitting line, but even then, however carefully the work is cut, further contact fitting would be necessary. This is a case when fitting may be a dual process, involving geometry and template. The drawing-board, if it is quite straight, is suitable on which to shape the manhole, which is screwed to the board at the correct distance from the centre. A template similar to Fig. 8 is made with a dowel as shown. This, of course, gives the accurate fitting shape. If the job is very large, instead of the template swinging from a centre, it could be guided by a circular strip A, fastened to the drawing-board with a corresponding check B on the template, as indicated by the dotted lines at Fig. 8. This is a method that is often adopted when a loam body is made in the foundry for a cylindrical pattern, and the details made of wood have to fit accurately in position.

Fitting Ribs.

Ribs are equally as difficult to fit as branches or bosses, and sometimes much more so. If a rib is in a vertical position in the mould, unless it has been very carefully fitted, it may tear the mould badly when being withdrawn. Thus it is always advisable to taper ribs as much as possible. Even when the position of the ribs is given on the drawing, and this is not always done, the patternmaker should scrutinise the design carefully, to make sure that bolt holes are not being fouled and also that the rib will not be in the way of other connections. Unlike bosses, ribs have to be fitted the finished thickness, and whilst one patternmaker will make one or two marks on the pattern, by means of a long-toothed gauge or a surface gauge, another more methodical workman will pin strips temporarily on the work, against which the ribs can be pressed when being fitted. The latter is the more satisfactory way, as a better fit is almost invariably obtained and in a fraction of the time that would otherwise be taken. When ribs are on a pattern joint they should invariably be "let into" the pattern. As to whether, in such cases, it is better to split the rib and fit a half thickness to each pattern section depends to a great extent on the size of the work. Thin ribs should not be split. If they are checked into the drag half of the pattern the top half may be recessed to clear or the ribs may be reduced in thickness to allow of a close joint being made. When a rib must be left loose in order that it will deliver from the sand it is advisable, when it is practicable, to check it or house it into the pattern, and when this course presents difficulties, to insert dowels, even if they are of wire 1-16 in. thick.

A SERIOUS FIRE broke out at the premises of the South Wales Electric Welding Company at the King's Dock, Swansea, on Monday, considerable damage being done.

OWING to the heavy increases in the already high poor-rate, the principal iron and steel manufacturers of the Darlaston district appointed a deputation to wait upon the local Board of Guardians to emphasise the serious effects to trade of such a heavy burden. A petition was presented, in which it was stated that the present high rates were crippling the industries of the district and were responsible in a very great measure for the unemployment which exists. They further point out that unless the present rate of expenditure is curtailed, and greater supervision exercised, operations will be suspended and works will be closed, and in consequence conditions would become even worse than they are at present. The petition was signed by nineteen firms in the Darlaston area.

"Perfect" Castings.

BY F. C. EDWARDS.

There are few words in the English language capable of so many interpretations as that of the adjective "perfect." The reason is, of course, that no two individuals think alike; and, in balancing points, "perfect" agreement as to what constitutes "perfection" is, therefore, seldom attained.

Where castings are concerned, this diversity of opinion is often the cause of friction between the foundry and other departments. Furthermore, it is a frequent source of scrap. It does not seem to be sufficiently realised that, though a casting may occasionally be produced, say, for exhibition purposes, which, as the acme of perfection, may be termed "a work of art," efficient production must of necessity lie in a less elevated region of accomplishment. In common fairness to the foundry, then, the term "perfect" may be quite justly applied to castings that are best suited for the particular purpose for which they are ultimately intended—*judged in the light of every-day foundry practice.*

The root of the trouble is sometimes found in the assumption on the part of the drafting room that the foundry can produce any casting which human ingenuity can devise. Such an assumption may, indeed, be literally true, but ordinary practice imposes limits to the possibilities of the foundry if "perfect" castings are to be turned out as a commercial proposition.

Another fruitful source of disagreement as to the application of the term "perfect" is found in the attempt to reduce machining allowances beyond a reasonable irreducible minimum. A sand mould never will produce a casting as uniformly "perfect" as a die casting can be produced; if it could do so there would be no need for any machining operations. Perhaps it is because this is so obvious that it is so often overlooked. Particularly is this the case where broaching and similar operations are carried out on mass-production components. Here, on account of the fine margin allowed, castings are frequently rejected that would be regarded as "perfect" by all practical foundrymen, "perfect," that is, when judged by those who possess a clear and adequate conception of all the factors operating in the production of castings.

Or, again, the foundry may be in the dark as to the ultimate purpose of the casting; where machining is required; where—for some special reason perhaps—it is essential that the casting should agree "perfectly" with the pattern; where, in order to secure continuous uniformity of shape, gates may or may not be placed. Who has not seen an unsightly mess left, after the removal of the gate, on an otherwise "perfect" casting? Perhaps the position may have been the best from the moulder's point of view, but if he had known that his gate (badly trimmed off, perhaps) would be the first thing to meet the eye on the casting, he would probably have found for it a less conspicuous position.

Here, a slight modification in design would often enable the foundry to overcome the unsightly finish left after the removal of the gate, and so the more easily to produce the "perfect" casting. For example, one frequently finds a casting somewhat concave round about the gate, which cannot be ground out without taking that part of the casting below the general level; and if the castings are thin, say ¼ in., the case is hopeless. But by giving to the sides of the castings where they are gated a convex instead of a flat surface—which can often be done without materially affecting design (it may, indeed, enhance the appearance of the casting), the gates can be removed as neatly as though they had never existed, and in this particular, at least, "perfection" may be attained.

It would appear, therefore, that a working agreement as to the meaning of the term "perfect" can only be reached where the designer, on the one hand, has a clear conception of foundry possibilities, and keeps his required standard of foundry attainment within reasonable bounds and, on the other, where the foundry is well-informed as to the uses to which the castings are to be put. Obviously, efforts made towards "perfection" tend to reduce the percentage of waster castings.

Manufacture of Synthetic Cast Iron in the Electric Furnace.*

The author discusses experiments carried out in 1918 at Portland, Ore., with an electric furnace of 600-kw. capacity, and others made in 1919 in a 2-ton furnace of 750-kw. capacity. Firebrick was used in the arch and the lining of the furnace, and silica for the bottom, after trials with carbon bottoms had been abandoned. When smelting turnings and borings the most efficient operation was obtained by charging every 30 min. and tapping every 2 hr. A charge of 200-300 lbs. of anthracite was first placed in the furnace bottom, followed by the turnings and borings and the coal, silicon, manganese, lime, and spar. During the operation the molten iron filters through a layer of 4-6 in. of incandescent coal and becomes thoroughly carbonised. When semi-steel is required but little carbon is added, and it is found better to run single charges and melt down the complete charge before tapping. The author describes the production of pig-iron and grey iron for direct foundry use, and the action of the lime and spar used for forming a basic slag. Analyses are given of consecutive heats to demonstrate the control of the electric furnace in producing pig-iron and foundry iron. The operating costs per ton of iron tapped from the furnace (not including fixed charges) are tabulated. It is stated that working one shift per 24 hr. the cost is $40.33; two shifts, $30.18; and three shifts, $27.4; with power at 1.25, 1, and 0.8 cent. per kw. for one, two, and three shifts respectively, and scrap at $10 per ton. Smelting iron ore with scrap is not considered to be economical owing to the greatly increased power required to smelt the ore.—W. L. MORRISON. (*Chem. & Met. Eng.*, 26, 312-316.)

Paris Congress and Exhibition.

At the last meeting of the Council of the Association Technique de Fonderie, Mons. Ramas presiding, the General Secretary, Mons. Camille Didier, brought to the notice of the meeting the letters received in answer to the invitations sent to the American Foundrymen's Association and the Institution of British Foundrymen. He was pleased to note that the Americans had promised their support, but the British had made reservations. Mons. Ronceray was requested to continue negotiations in order that a favourable reply might be received from the British association.

The position of the Institution of British Foundrymen with reference to this is to be re-considered at a meeting to be held in York next Saturday, after which no doubt the position of the British will be quite clearly defined. We can assure the Institution that there should be a reasonable response, if our appeal can be taken as any criterion. No less than fifty applications for detailed information have been received, emanating from large foundries, the President and past-Presidents of the Institution.

If, ten months before the Congress, fifty people propose to take part, the French Association can rest assured that by next September they will have good representation from the British, and the Institution on their side can rely on adequate support for any effort they may put forward.

London Branch Annual Dinner.

We are asked by the honorary secretary of the London Branch to announce that any members of the Institution who will be in London on December 15 are cordially invited to the annual dinner, which will take place at 7 for 7.30 p.m., at the New Villa Villa Restaurant, Gerrard Street, on this date. Tickets are 10s. 6d.

MR. WILLIAM PATTERSON, of Heaton, who was for many years in the employ of Sir W. G. Armstrong, Whitworth & Company, Elswick, and who since 1914 had resided in Glasgow, and acted as inspecting engineer for the firm in Scotland, has died.

* Institution of Civil Engineers Abstract.

Trade Talk.

THE reduction of 4s. per week in the wages of employés in Admiralty dockyards was put into operation last week.

A LARGE number of men at the Central Engineering Works, Ystradmynach, in the Rhymney Valley, came out on strike last week owing to a wages dispute.

THE LAXEY LEAD MINES, near Douglas, I.O.M., which were only re-opened three months ago, have been seriously damaged by fire, but work is being continued underground

RICHARD THOMAS & COMPANY, LIMITED, are at present constructing a wharf at Llanelly, at which the company propose breaking up an obsolete warship they recently acquired.

MR. ALFRED C. TURNER, 23, Budge Row, Cannon Street, E.C.4, has been appointed London agent for the General Refractories Company, Limited, of Kelham Island, Sheffield.

THE BUSINESS of Albert Day & Sons, iron and brass-founders, of Mark Foundry, near Highbridge, Somerset, is offered for sale. Arrangements are in the hands of J. A. Palmer & Sons, Burnham-on-Sea.

MAJOR J. CALDWELL read a paper on "Electric Welding," illustrated by experiments, at a meeting of the Yorkshire Association of the Institution of Civil Engineers, held on November 24, in the Philosophical Hall, Leeds.

THE MEMBERS of the Sheffield Tool Trade Technical Society met recently in the Mappin Hall, Department of Applied Science, Sheffield University, when Mr. A. W. Macaulay read a paper on "Ball Bearings." Mr. M. W. Clayton presided.

ARTHUR LEE & SONS, LIMITED, Crown Steel and Wire Mills, Bessemer Road, Sheffield, have established a London branch office of their own at 40-43, Norfolk Street, W.C.2. Hitherto the company have been represented by B. Holland & Company.

"INDUSTRIAL WASTES" was the subject of an interesting discussion at the last monthly meeting of the West Cumberland Association of Chemists and Chemical and Metallurgical Engineers, at Workington. Mr. G. J. Valentine presided.

NOTICE of the termination of the agreement of 1918 has been posted at Vickers' shipyard, Barrow, which will reduce the number of men employed as platers' helpers. The unions are protesting against the reduction and ask for a continuance of the agreement.

THE NEWCASTLE BRANCH of the Institution of British Foundrymen met on November 29 in the Neville Hall. Mr. H. J. Young (president) presiding. An interesting lecture on dry sand moulding was given by Mr. J. O. Nicholson, and a long discussion followed.

E. CAPPER ROBSON & COMPANY, LIMITED, will in future trade as Robson Refractories, Limited, the latter company having now taken over the sole selling rights of "Cupoline" for this country. The address remains the same, namely, 1, North Road, Darlington.

ACCORDING TO "Lloyds' Register of Shipping," 80 vessels of 93,715 tons were totally lost, condemned, etc., during the quarter ended June 30, as reported up to October 17, comprising 30 steel vessels of 60,156 tons, 7 iron of 2,981 tons, and 43 wood and composite of 30,578 tons.

THE SHEFFIELD FOUNDRY TRADE TECHNICAL SOCIETY had their second meeting last week, when Mr. R. Buchanan, a past president of the Institute of British Foundrymen, lectured on "The Foundry Cupola," illustrating his subject with views of British, Continental and American cupolas.

SIR HUGH REID, BART., was elected president of the Glasgow Association of Students of the Institution of Civil Engineers at the opening meeting of the session, held on November 22. Sir Hugh Reid, in his presidential address, dealt with the outstanding features of locomotive design as shown in modern practice. Thereafter a paper on "Puddle Trenches" was read by Mr. Oscar Manning, and a discussion followed.

SOME TIME AGO Kerr, Stuart & Company, Limited, were invited to form a company in India for the purpose of manufacturing railway locomotives. The directors of the company state that they have decided to accept the invitation after having fully considered and investigated the position. An undertaking known as the Peninsular Locomotive Company has been formed, the capital having been subscribed privately in India. The production of locomotives on an extensive scale is expected to begin shortly.

THE SECRETARY of Ewart & Collis, Limited, has sent to shareholders a letter containing an offer to purchase shares of the company. Holders are asked to advise the secretary on or before Monday, December 4, if they desire to accept or reject the offer. Subject to 90 per cent. in value of the preference shareholders and 75 per cent. in value of the ordinary shareholders, the buyers are prepared to purchase from each shareholder his shareholding in the company at 9s. per fully-paid preference share of £1 each and 3s. per fully-paid ordinary share of £1 each.

IRON AND STEEL MARKETS.

Pig-iron.

With the end of the current year now in sight the position in the pig-iron industry is hardly likely to undergo any material change, markets in the chief centres experiencing quiet conditions pending the stock-taking arrangements usual at these periods. In South Staffordshire better reports to hand of an expansion in the engineering departments has encouraged the demand for foundry pig, with the result that quotations keep very firm, while conditions are also improved in the case of forge iron. More of this quality is being sold, but, of course, the demand is very much below normal. The supporting influence of an improved inquiry is still backed up by the high price of coke, so that there is now little or no margin in prices, a fact which makes sellers rather disinclined to make forward contracts. It would be a great relief to see costs falling and the industry restored to a better and more profitable balance. Reports from Lancashire are couched in a more pessimistic strain than usual, although here foundry pig is a little firmer than previous quotations indicated. It is understood that the Lancashire ironfoundries have been getting more work lately, and the general belief is that the trade is not in such a bad condition as it was a few months back. The selling of Scotch pig-iron in this district has not altogether recovered from the effect of the high prices which were quoted during the period of American buying, but these prices here are now a little more reasonable. At Sheffield there is some quiet buying of foundry and basic iron, but the volume of business is rather smaller than of late. All makers, Lincolnshire and Derbyshire, are holding firmly to the quotations, and in some instances are asking slightly higher prices, but users show no great readiness to accept these. Conditions in the Cleveland iron trade continue somewhat inactive, the home demand having temporarily slackened off, and with prices showing a rather easier tendency consumers are disposed to adopt a waiting attitude. Fuel costs, however, are not coming down to any substantial extent, and until they do it is difficult to see how any further concession in pig-iron prices can be effected. Export business with the Continent continues to be handicapped by the exchange situation, and as regards America, there is nothing doing so far as ordinary foundry qualities are concerned. With regard to price movements, No. 1 and silicious, which have stood for a long time past at 97s. 6d., can be done at about 96s. 6d., and No. 3 G.M.B. is unchanged from last week at 92s., with No. 4 foundry 87s. 6d., and No. 4 forge about 82s. 6d. Mottled and white are negotiable at round about 80s. per ton.

In the East Coast hematite market the improvement in the finished steel trade is reflected in the demand, which is, if anything, rather stronger than last week. There is a fairly active inquiry, and substantial quantities are being sold to South Wales. Continental inquiry, too, is better, and moderate parcels are being shipped. The feeling all round is undoubtedly more buoyant, and recent quotations now certainly represent a minimum. East Coast mixed numbers stand at about 93s. to 93s. 6d. per ton, with the premium for No. 1 unchanged at 6d. to 1s. per ton. Messrs. Gjers, Mills & Company, Limited, and Messrs. the Seaton Carew Iron Company, Limited, are each putting in another furnace on hematite. Conditions in the Cumberland and North Lancashire hematite industry are also more active with prices firm. Bessemer mixed numbers being quoted at 110s. per ton delivered Glasgow or Sheffield.

Finished Iron.

The outlook in this section of the iron trade, though now regarded as much more satisfactory, is still largely dependent upon the early realisation of better conditions in the matter of costs of production and rail transport, which are to-day the principal factors hindering an expansion of business. Manufacturers are, however, fairly sanguine of a change for the better in the coming year, and meantime are experiencing a little more disposition on the part of buyers to entertain ideas of forward offers. It is at all events satisfactory to note some relaxation of the pressure of foreign competition in bar iron, due in a measure to the fact that Continental makers, having already booked substantial forward business, are no longer in a position to guarantee prompt deliveries of new orders. Naturally, under such circumstances, the Midland market is a little more cheerful, and nut and bolt bars are more steadily quoted at £9 15s., though possibly an attractive order would be accepted for rather less. Trade in crown bars is described as rather more regular, though there is still room for a big increase in the volume of demand before there will be any pressure. The top price obtainable is still £10 15s., and there has been nothing to make it more remunerative. Marked bars are quietly steady, while the outlook is regarded as a little more promising. The competition of steel keeps the iron strip trade most depressed.

Scrap.

As previously reported, the outstanding feature in the scrap metal markets of late has been the increased strength of heavy steel qualities and some revival of demand for foundry material. Both at Sheffield and South Wales the result has been a stiffening of prices for most descriptions of steel scrap. In the first-named market contracts up to about the middle of 1923 are offering, but sellers are not very desirous of accepting them at the prevailing prices, for it would cause little surprise if the material reached considerably higher figures before next year is far advanced, owing to the comparatively short supplies. At Middlesbrough, also, the scrap market is, on the whole, showing a more active tendency, particularly as regards heavy steel scrap, for which the demand appears to be steadily growing stronger. Prices have correspondingly hardened, and the general quotation is now around 70s. per ton. Steel turnings and cast-iron borings are also in good demand, and realise as much as 56s. per ton. Heavy cast-iron machinery scrap is still on the quiet side, but the quotation is firm at 72s. 6d. to 75s. per ton. There is a little more interest being taken in heavy wrought-iron scrap, piling material realising in the region of 67s. 6d. per ton, f.o.r., this district, with heavy forge 72s. 6d. to 75s. per ton. With the exception of piling scrap all quotations are delivered works.

Steel.

Although actual business in steel and its various products is at the moment still much below normal levels, the future prospects of the industry may be regarded as distinctly promising, some satisfactory contracts for new shipbuilding having already been placed, while the engineering and foundry branches may be confidently expected to benefit largely from the various schemes of railway and road constructional developments now under consideration to meet the unemployment emergency confronting Parliament. As regards semi-products, Sheffield makers report a more satisfactory demand, basic billets being bought with a good deal of freedom, and at last acid qualities are showing a more active condition. Quotations are unchanged. Business in most classes of steel is improving, and all round there is increasing confidence that the worst is over. The crucible steel trades continue to improve, electric steels not having yet replaced this section, as has been suggested by various interested parties from time to time. This improvement is interesting in that it is for carbon steels chiefly and not for high-speed steel. In the market for alloys, ferro-silicon is in only moderate request at the moment, and stocks are still fairly plentiful in all grades. Quotations are unchanged with most of the business passing done in 45 per cent. grade. A little business is still passing in briquetted ferro-silicon 80/90 per cent. Si., made from Government stocks of powdered silicon. The tinplate market is somewhat less active, but the demand is steady and prices firm. Although it might be possible to secure an offer at 19s. 6d. per standard box here and there, the general run of quotations is 3d. higher than the minimum.

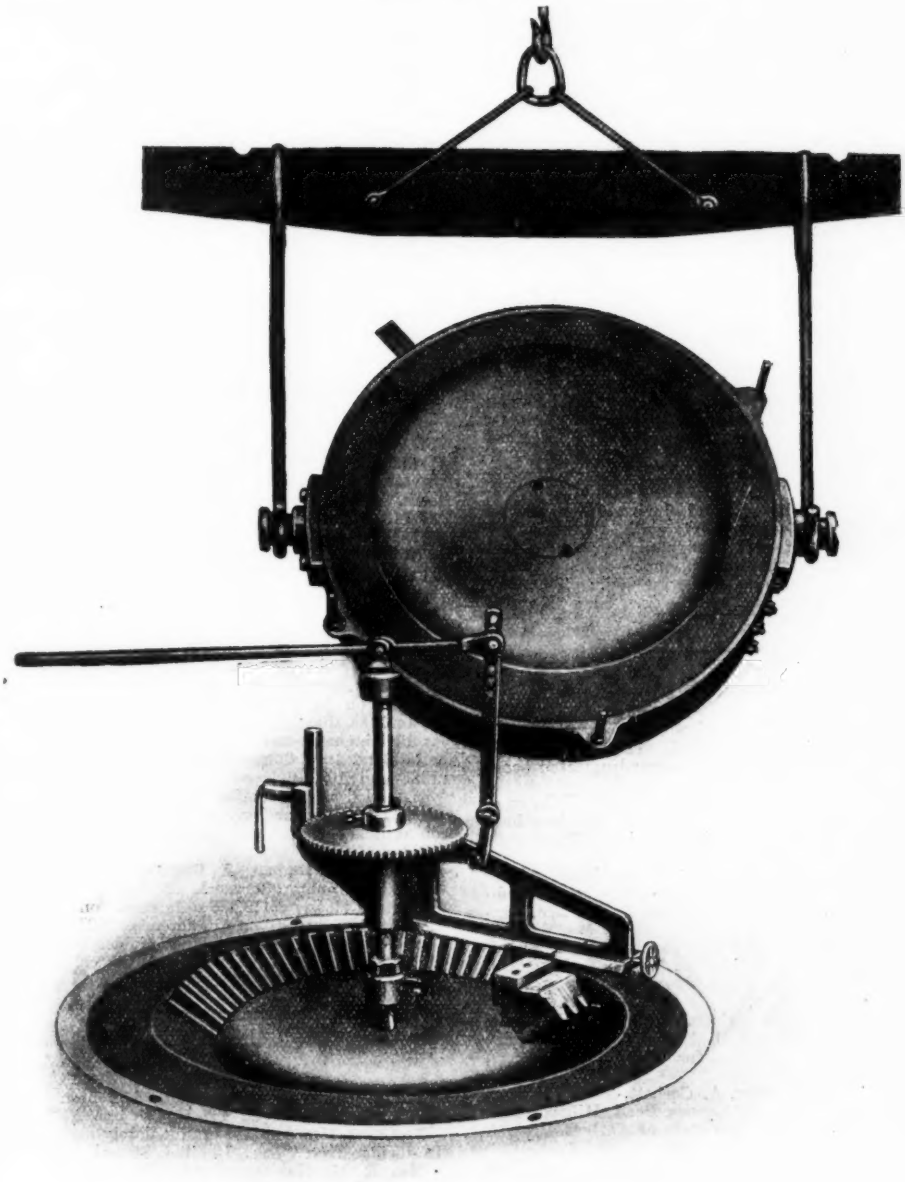
Metals.

Copper.—Business recently in the market for this metal has reverted to quieter conditions, and in the absence of speculative support dealings have been on a more restricted scale. Values of standard copper after a relapse made a slight recovery at the week-end, but have not yet regained the comparatively high levels obtaining in mid-November. In America the market for standard copper has been extremely quiet of late, and finally quotations are just the shade easier. This may be ascribed to the falling off of export demand, due to present political uncertainties, the wild movements in exchange, and particularly to the extraordinary fluctuations of the franc, which have checked buying on the part of French consumers. The ease in electrolytic, reflected on the market for standard copper, led to realisation of this description, with a resultant shrinkage in values. Current quotations:—*Cash*: Wednesday, £61 12s. 6d.; Thursday, £62; Friday, £62 5s.; Monday, £62 5s.; Tuesday, £62 5s. *Three Months*: Wednesday, £62 10s.; Thursday, £62 17s. 6d.; Friday, £63 2s. 6d.; Monday, £63 2s. 6d.; Tuesday, £63 2s. 6d.

(*Continued on page 478.*)

The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

Patent No. 5049.



THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

JAMES EVANS & CO., BRITANNIA WORKS,

(MANCHESTER), LIMITED.

BLACKFRIARS, MANCHESTER.

IRON AND STEEL MARKETS.—*Continued.*

Tin.—Following the recent substantial relapse in values the market for standard tin has maintained a fairly level of quotations, with only slight fluctuations confined within a rather limited range. The chief reason for this weakness has been heavy liquidation and "bear" selling, induced by the changed aspect of the Eastern situation in regard to the disposal of the controlled surplus, which may easily take another year or so to accomplish instead of this surplus being released *en bloc*, as had been rather prematurely anticipated. Sentiment has been aggravated by the reported abnormally heavy Straits shipments for last month, estimated at about 6,000 tons. In the rather dislocated and uncertain state of the market America has largely abstained from further buying, although the sharp fall in our market has been to some extent counteracted by the rise in the dollar rate of sterling. Current quotations: — *Cash*: Wednesday, £174; Thursday, £174; Friday, £175; Monday, £174 5s.; Tuesday, £176. *Three Months*: Wednesday, £175; Thursday, £175 2s. 6d.; Friday, £176; Monday, £175 7s. 6d.; Tuesday, £177.

Spelter.—The market for this metal continues strong, with values again on the up-grade, corresponding with a similar tendency in America. The price of spelter there has broken sharply, and the break has been more than reflected on this side. Consumptive demand here completely died down on the fall, but in view of the statistical position of the metal we do not think that a revival of demand can be long delayed. Current quotations:—*Ordinary*: Wednesday, £39; Thursday, £39 5s.; Friday, £39 10s.; Monday, £39 10s.; Tuesday, £40.

Lead.—Consumptive demand during the past week has been a little quieter, but with supplies still restricted values of soft foreign pig have been well maintained. Current quotations: — *Soft foreign (prompt)*: Wednesday, £26 2s. 6d.; Thursday, £26 2s. 6d.; Friday, £26 2s. 6d.; Monday, £26 2s. 6d.; Tuesday, £26 2s. 6d.

Gazette.

MR. W. H. BUTT, 2, Wordsworth Terrace, trading as Hall Engineering Company, Lower Maiden Street, both Weymouth, engineer, has been adjudicated bankrupt.

MR. F. C. DOWSETT, 204, Goswell Road, E.C., engineer and toolmaker. R.O. November 21, has been adjudicated bankrupt. Examination Bankruptcy Court, March 14, at 11.

MR. G. RICHARDS, 14, West Bute Street, Bute Docks, Cardiff, iron and steel agent, has been adjudicated bankrupt. First meeting, 34, Park Place, Cardiff, December 11, at 11.

HARDY CONSTRUCTION COMPANY, LIMITED, Manchester, engineers, in liquidation. Mr. G. R. Woollard, 5, John Dalton Street, Manchester, accountant, has been appointed receiver.

TRADING UNDER the style of Collett and Davis, Messrs. J. H. Collett and H. E. Sheldon, 72, Moseley Road, Birmingham, hearth furniture manufacturers, have dissolved partnership.

MESSRS. T. M. CORBETT, A. Corbett, and R. Gibson, coal cutting engineers, 38, Lennox Road, Hillsborough, Sheffield, trading under the style of Corbett Bros. & Gibson, have dissolved partnership.

TRADING UNDER the style of F. Brownsmith & Company, Messrs. C. H. Walters and F. W. Brownsmith, 14, New Street, Birmingham, metal merchants, have dissolved partnership. Debts by Mr. F. W. Brownsmith.

MESSRS. W. C. M'CLELLAND & G. B. BURNSIDE, trading under the style of Burnside & Company, 1,041, Argyle Street, Glasgow, engineers, have dissolved business. Debts by Mr. G. B. Burnside, who continues.

IN THE MATTER of the Hydraulic (L. A. C.) Trucks, Limited, a petition has been presented by J. Maddock & Company, Limited, Oakengates, malleable ironfounders. December 5. Agents, Willis & Willis, 59, Chancery Lane, E.C., solicitors.

TRADING UNDER the style of E. Bingham & Company, Messrs. E. C. Bingham, H. G. Bower and F. Leitch, Scottish Works, Allen Street, Sheffield, cutlery manufacturers, have dissolved partnership. Debts by E. C. Bingham and H. G. Bower, who continue the business.

THE public examination took place at Walsall last Thursday (November 23) of William H. B. Troman and Henry Lee Tooth, trading as W. H. B. Troman & Company, 34, Rooth Street, Wednesbury (Staffs), iron and steel merchants. The statement of affairs showed liabilities £413, and a deficiency of £411. The causes given for the failure were lack of capital, heavy trading expenses, including railway rates, salaries and hauling charges. The examination was adjourned until December 12.

Company News.

Joseph Tucker, Limited, Lichfield Chambers, 1, Leicester Street, Walsall.—Capital £2,500 in £1 shares. Ironfounders, etc.

Muta, Limited, 17, Farringdon Street, London, E.C.—Capital £3,000 in £1 shares. Directors: D. D. Walker and F. L. Dadd.

Onward Engineering Company, Limited, 178, Dock Street, Fleetwood.—Capital £2,000 in £1 shares. Directors: J. H. Wood and W. H. Littler.

Flinders, Limited, 121, High Street, Colchester.—Capital £500 in £1 shares. General Engineers. Directors: J. Warner, A. F. Hitchcock and M. C. Hitchcock.

Harrison Lee & Sons, Limited, 1, High Street, Limerick.—Capital £15,000, in £1 shares. Iron founders. Directors: R. N. Lee, Mrs. E. M. Nelson and J. Lee.

Marshall & Duguid, Limited.—Capital £5,000 in 4,000 ordinary and 1,000 preference shares of £1. Engineers. Directors: W. Easton, jun., R. S. Marshall and G. K. Johnston.

Lacey-Johnson & Company, Limited, 83, Victoria Street, London, S.W.1.—Capital £4,000 in £1 shares. Engineers. Directors: R. Lacey-Johnson, W. E. Riche, and W. D. Harding.

John Williams & Co. (Wishaw), 1922, Limited, Excelsior Iron Works, Wishaw.—Capital £30,000 in £1 shares. Iron, steel and coal merchants. Directors: F. Williams and A. H. Williams.

Marshall Electrical Company, Limited, 50, Marshall Street, London, W.1.—Capital £3,000, in 2,300 5 per cent. cumulative preference and 700 ordinary shares of £1. Directors: R. W. L. A. Ham (chairman) and W. N. Ibbotson.

Baldwins, Limited.—Settlement with Revenue authorities now made with exception of few matters still outstanding, and it is expected that annual meeting will be held not later than January 31, 1923. Declaration of dividend on ordinary for year passed.

Nineteen Nineteen Metal Company, Limited, 39, Corporation Street, Birmingham.—Capital £3,000 in £1 shares, to acquire the businesses now or formerly carried on by F. Mann, F. D. Longmore, and J. Gittens as the "Nineteen Nineteen Metal Company" at Birmingham, and Swan Village, West Bromwich.

Midland Iron Company, Limited.—Balance-sheet for 1921 and 1922 delayed in consequence company not yet settled with taxation authorities; trading operations for past year have resulted in loss; no dividend on ordinary shares, but preference dividend for year 1922 declared.

Bolckow, Vaughan & Company, Limited.—Debit, £85,369; brought forward, £203,507; balance after deducting loss, £118,138; interest on debentures, £80,000; dividend on preference, £23,604, leaving carried forward, £14,534; no dividend on ordinary shares; expenditure during year on colliery plants, steel works, etc., £355,113.

Personal.

SIR WILLIAM RAEBURN, M.P., has been re-elected chairman of the Clyde Trust.

THE LATE MR. J. P. WIBRICK, lately manager of the Dudbridge Iron Works, Limited, Stroud, left £1,383.

MR. E. G. HARCOURT, managing director of Harcourts, Limited, brassfounders, Moseley Street, Birmingham, has retired.

THE LATE MR. RICHARD MOON, J.P., of Penyvoel House, Llanymynech, Oswestry, engineer, left estate of the gross value of £128,340, with net personalty £124,255.

MR. W. J. BELSEY, manager of the Glasgow branch of the British Thomson-Houston Company, Limited, has been appointed manager of the marine department at Rugby, being succeeded at Glasgow by Mr. J. Miller.

MR. E. W. LEIGHTON has resigned his position with the Mond Nickel Company, Limited, in order to devote the whole of his time to the affairs of the Anglo-Ural Platinum Trust Company, Limited, of which he is the managing director.

MR. GEORGE SCOBY SMITH has resigned his position of commercial manager of Bolckow, Vaughan & Company, Limited. He has accepted the position of commercial superintendent, and the directors have elected him to a seat on the board.

Copper Alloy Pipe Fittings.—The British Engineering Standards Association, 28, Victoria Street, Westminster, S.W.1, has issued B.S. Specification No. 99, 1922, for copper-alloy pipe fittings, screwed for low and medium pressure British standard copper tubes (primarily for domestic and similar work).

Telephone: 21, Penistone. Telegrams: "Durranns, Penistone."

ESTABLISHED 1863.

JAS. DURRANS & SONS., LTD.

Phoenix Works, Penistone NEAR SHEFFIELD.

BLACKING
PLUMBAGO
CORE GUM
WHITE DUST
COAL DUST

Manufacturers of

FOUNDRY EQUIPMENTS.

Ladles, Cupolas, Fire Bricks, Ganister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Write for illustrated catalogue on Blacking and Foundry Requisites, also for our latest Price List.

TELEGRAMS: "IRON BILSTON."

West Midland Refining Co.,

Bilston.

COLD BLAST IRONS

for Chilled Castings.

Chills and analysis guaranteed.

CHARCOAL

REFINED HEMATITES

for Malleable Castings.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	62	5	0
Three months	63	2	6
Electrolytic	69	7	6
Tough	65	10	0
Best selected	65	10	0
Sheets	96	0	0
India	84	0	0
Wire bars	69	5	0
Do. Dec.	69	5	0
Do. Jan.	69	5	0
Ingot bars	69	5	0
H.C. wire rods	74	5	0
Off. aver. cash, Nov.	62	17	0 5/11
Do. 3 mths., Nov.	63	14	3 9/11
Do. Settlement Nov.	62	17	1 10/11
Do. Electro, Nov.	70	9	3 8/11
Do. B.S., Nov.	66	8	9
Aver. spot price, copper, Nov.	62	16	1 3/4
Do. Electro, Nov.	70	14	3½

Solid drawn tubes 13½d.
Brazed tubes 13½d.
Wire 10½d.
Yellow metal rods 6½d.
Do. 4x4 Squares 8½d.
Do. 4x3 Sheets 9½d

BRASS.

Solid drawn tubes 11½d
Brazed tubes 13½d
Rods, drawn 10½d.
Rods, extruded or rolled 6½d.
Sheets to 10 w.g. 10d.
Wire 9½d.
Rolled metal 9½d.

TIN.

Standard cash	176	0	0
Three Months	177	0	0
English	176	0	0
Bars	178	0	0
Chinese	175	0	0
Straits	177	15	0
Australian	177	5	0
Eastern	177	10	0
Banca	176	15	0
Off. aver., cash Nov.	179	8	9 12/23
Do. 3 mths., Nov.	180	3	5 13/23
Do. Sttlment Nov.	179	8	7 7/11
Aver. spot, Nov.	179	7	3¼

SPELTER.

Ordinary	40	0	0
Remelted	36	0	0
Hard	28	0	0
Electro 99.9	43	10	0
English	39	15	0
India	29	0	0
Prime Western	39	10	0
Zinc dust	49	0	0
Zinc ashes	11	0	0
Off. aver., Nov.	36	18	9
Aver., spot, Nov.	38	0	2¾

LEAD.

Soft foreign ppt	26	2	6
English	27	5	0
Off. average, Nov.	25	12	2 13/23
Average spot, Nov.	26	3	5½

ZINC SHEETS.

Zinc sheets, English	41	10	0
Do. V.M. ex. whf.	42	0	0
Dutch	42	0	0
Rods	49	0	0
Boiler plates	40	10	0
Battery plates	42	10	0

ANTIMONY.

English regulus	27	0	0
Special brands	33	10	0
Chinese	25	0	0
Crude	17	5	0

QUICKSILVER.

Quicksilver 12 5 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—
45/50% 11 7 6
75% 20 0 0

Ferro-vanadium—
35/40% 17/3 lb. va.

Ferro-molybdenum—
70/75% c. free 9/6 lb. mo.

Ferro-titanium—
23/25%, carbonless 1/2 lb.

Ferro-phosphorus, 20/23%, £24

Ferro-tungsten—
80/85%, carbon free 1/5 lb.

Tungsten metal powder—
98/99% 1/11 lb.

Ferro-chrome—
4/6% car. £23 0
6/8% car. £22 0
8/10% car. £21 5

Ferro-chrome—
Max. 2% car. £54 0
Max. 1% car. £65 0
Max. 0.70% car. £73 0
67/70%, carbonless 1/7½ lb.

Nickel—99%, cubes or pellets £137 10

Cobalt metal—98/99% 12/- lb.

Aluminium—98/99% £100

Metallic Chromium—
96/98% 4/6 lb.

Ferro-manganese (net)—
76/80%, loose £15
76/80%, packed £16
76/80%, export £14 10

Metallic manganese—
94/96%, carbonless 2/3 lb.
Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten s. d. 2 6
Finished bars, 18% tungsten 3 0
Per lb. net, d/d buyers' works.

Extras—
Rounds and squares 3 in. to 8 in. inclusive 4d. lb.
Rounds and squares under ½ in. to ¼ in. 3d. lb.
Flats under 1 in. by ¾ in. to ½ in. by ¼ in., and all sizes over four times in width over thickness 3d. lb.
Bevels of approved sizes and sections 6d. lb.
If in coils 3d. lb.
Packing £3 ton.
Bars cut to length 10% extra

Scrap from high-speed tool steel—
Scrap pieces 3d.
Turnings and swarf 1d
Per lb. net, d/d steel makers' works.

SCRAP.

South Wales—	£	s.	d.	£	s.	d.
Heavy Steel	3	15	0	4	0	0
Bundled steel & shearings	3	0	0	3	17	6
Mixed iron & steel	3	1	6	3	10	0
Heavy cast iron	3	10	0	3	15	0
Good machinery for foundries	3	15	0	4	0	0

Cleveland—			
Heavy steel	3	10	0
Steel turnings	2	16	0
Cast-iron borings	2	15	0
Heavy forge	3	13	9
Bushelled scrap	2	16	3
Cast-iron scrap	3	13	9

Lancashire—			
Cast iron scrap	3	15	0
Heavy wrought	3	2	6
Steel turnings	2	2	6

London—	£	s.	d.
Copper (clean)	57	0	0
Brass (clean)	32	0	0
Lead (less usual draft)	22	0	0
Tea lead	20	0	0
Zinc	22	0	0
New aluminium cuttings	64	0	0
Braziery copper	48	0	0
Gun metal	44	0	0
Hollow pewter	130	0	0
Shaped black pewter	90	0	0

Above are merchant's buying prices delivered yard.

PIG-IRON.

N. E. Coast—	
Foundry No. 1	96/6
Foundry No. 3	92/-
Forge No. 4	82/6
Mottled	81/6
Hematite No. 1	94/-
Hematite M/Nos.	93/3
Midlands—	
Staffs. common	—
„ part-mine forge	—
„ „ foundry	—
„ Cold blast, ord.	190/-
„ „ roll iron	200/-
„ basic	—
Northants forge	70/- to 72/6
„ foundry No. 3	77/6 „ 80/-
„ basic	80/-
Derbyshire forge	75/-
„ foundry No. 3	82/6
„ basic	80/-
Scotland—	
Foundry No. 1	99/6
„ No. 3	94/6
Hematite M/Nos.	107/6
Sheffield (d/d district)—	
Derby forge	85/6
„ foundry No. 3	87/6
Lincs. forge	86/6
„ foundry No. 3	87/6
„ basic	86/6
E.C. hematite	104/5
W.C. hematite	110/-
All d/d in the district.	
Lancashire (d/d eq. Man.)	—
Derby forge	—
„ foundry No. 3	90/-
Northants foundry No. 3	—
Cleveland foundry No. 3	—
Staffs. foundry No. 3	—
Lincs. forge	—
„ foundry No. 3	—
Summerlee foundry	112/6
Glengarnock foundry	114/6
Gartsherrie foundry	114 6
Monkland foundry	112/6

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.
Bars (cr.)	£10 10 to 11	10	0
Angles	£10 15 to 11	15	0
Tees to 3 united ins.	£11 to £12		
Nut and bolt	9	12	6
Hoops	14	0	0
Marked bars (Staffs.)	13	10	0
Gas strip	£10 10 to 10	15	0
Bolts and nuts, ¾ in. × 4 in.	16	10	0

Steel—			
Ship plates	£9 to 9	10	0
Boiler plates	12	10	0
Chequer plates	10	5	0
Angles	£8 12 6 to 9	0	0
Tees	£9 12 6 to 10	0	0
Channels	8	10	0
Joists	9	0	0
Rounds & squares 3-in. to 5½in.	9	5	0
Rounds, under 3in. to ¾in.	8	15	0
Flats, over 5in. wide and up	9	10	0
Flats 5in. to 1½in.	8	15	0

	£	s.	d.
Rails, heavy	8	15	0
Fishplates	14	10	0
Hoops	11	10	0
Black sheets, 24 g.	11	15	0
Galv. cor. sheets, 24 g.	17	7	6
Galv. fencing wire, 8 g. plain	16	0	0
Rivets, ½ in. dia	11	15	0
Billets, soft	6 0 0 to 7	0	0
Billets, hard	7 0 0 to 8	0	0
Sheet bar	6 15 0 to 7	7	6

PHOSPHOR BRONZE.

	Per lb basis
Strip	1 3
Sheet	1 3½
Wire	1 3½
Rods	1 2½
Tubes	1 6
Castings	1 1

Delivery 3 cwt. free to any town.
10% phosphor copper, £40 above price of B.S.
15% phosphor copper, £50 above price of B.S.
Phosphor tin (5%), £30 above price of English ingots.
CHARLES CLIFFORD & SON LIMITED, BIRMINGHAM.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	11d. to 1/5
Rolled—	
To 9 in. wide	1/5 to 1/11
To 12 in. wide	1/5½ to 1/11½
To 15 in. wide	1/6 to 2/0
To 18 in. wide	1/6½ to 2/0½
To 21 in. wide	1/7½ to 2/1½
To 25 in. wide	1/8½ to 2/2½
Ingots for spoons and forks	11d. to 1/5
Ingots rolled to spoon size	1/2 to 1/8
Wire round—	
3/0 to 10. G.	1/8¼ to 2/3½

with extras according to gauge

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	30.14
No. 2 foundry Valley	27.50
No. 2 foundry, Birm.	23.00
Basic	29.46
Bessemer	33.27
Malleable	30.96
Grey forge	28.77
Ferro-manganese 80 % delivered	100.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y, at mill	43.00
Bess. billets	38.00
O.-h. billets	38.00
O.-h. sheet bars	38.00
Wire rods	45.00

	Cents.
Iron bars, Phila.	2.27
Steel bars	2.00
Tank plates	2.00
Beams, etc.	2.00
Skelp, grooved steel	2.00
Skelp, sheared steel	2.00
Steel hoops	2.75
Sheets, black, No. 28	3.35
Sheets, galv., No. 28	4.35
Sheets, blue an'l'd, 9&10	2.50
Wire nails	2.70
Plain wire	2.45
Barbed wire, galv.	3.35
Tinplate, 100-lb. box	$4.75

COKE (at ovens).

Welsh foundry 35/-
„ furnace 25/-
Durham & North. fdy. 27/6 to 30/-
„ furnace 22/6 to 25/6
Other Districts, foundry 25/- to 30/-
„ furnace 21/6 to 24/6

SWEDISH IRON.

Bars, hammered basis sizes Basis price £22 to £23

	£ s. d.
Rolled Ordinary— Assortment ..	18 0 0
Nail Rods— Square, round and flats ..	to 18 10 0

Keg Steel nom. £38 to £40
Faggot Steel nom. £30 to £32

Blooms—
Single welded .. £10 to £11

Billets—
Single and double welded £13 to £14

Pig-Iron—
Grey, white or mottled .. £7 to £7 10 0

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

TUBES.

Up to and incl. 6 in.

Gas	..	57½%
Water	..	52½%
Steam	..	47½%

Tube prices are now free.

TINPLATES.

I.C. Cokes,	20×14, box	19/9
,,	28×20, ,,	40/6
,,	20×10, ,,	28/7½
,,	18¾×14, ,,	20/6
I.X.	,,	46/-
I.X.X.	,,	52/-
F.C.B.Y.	21×13⅝ ,,	36/6
C.V.B.G.	16¾×15, ,,	34/9
I.C.W.	20×14, ,,	17/10½
,,	28×20, ,,	35/9
,,	20×10, ,,	25/7½
,,	18¾×14, ,,	18/4½
Terneplates,	28×20, ,,	36 6

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.		
Nov. 29	61	12	6	inc.	2/6
,, 30	62	0	0	,,	7/6
Dec. 1	62	5	0	,,	5/-
,, 4	62	5	0	No change	
,, 5	62	5	0	,,	

Electrolytic Copper.

Nov. 29	69	5	0	No change	
,, 30	69	10	0	inc.	5/-
Dec. 1	69	15	0	,,	5/-
,, 4	69	7	6	dec.	7/6
,, 5	69	7	6	No change	

Standard Tin (cash).

Nov. 29	174	0	0	dec.	12/6
,, 30	174	0	0	No change	
Dec. 1	175	0	0	inc.	20/-
,, 4	174	5	0	dec.	15/-
,, 5	176	0	0	inc.	35/-

Tin (English ingots)

Nov. 29	174	0	0	dec.	12/6
Nov. 30	174	0	0	No change	
Dec. 1	175	5	0	inc.	25/-
,, 4	174	5	0	dec.	20/-
,, 5	176	0	0	inc.	35/-

Zinc Sheets (English).

Nov. 29	41	10	0	No change	
,, 30	41	10	0	,,	
Dec. 1	41	10	0	,,	
,, 4	41	10	0	,,	
,, 5	41	10	0	,,	

Spelter (ordinary).

Nov. 29	39	0	0	inc.	10/-
,, 30	39	5	0	,,	5/-
Dec. 1	39	10	0	,,	5/-
,, 4	39	10	0	No change	
,, 5	40	0	0	inc.	10/-

Lead (English).

Nov. 29	27	10	0	No change	
,, 30	27	10	0	,,	
Dec. 1	27	5	0	dec.	5/-
,, 4	27	5	0	No change	
,, 5	27	5	0	,,	

THE
ARMITAGE WORKS Co., Ltd.
Manufacturers of
Highly Refractory Bricks and Blocks
FOR ALL PURPOSES.

SPECIALITIES:
CUPOLA LININGS.
Ladle Bricks for Siemens Ladles.
Chequer Bricks, etc., for Siemens Furnaces.
Gas Producer Linings.

GROUND GANISTER
for Iron, Steel, and Brass Furnaces. Forced Draught Brass Furnaces. Semi-Silica or Semi-Ganister Bricks. Silica Cement.

DEEPCAR, Near Sheffield.

SHROPSHIRE IRON Co., Ltd.

Works:—
Hadley, Shropshire.

London:—10, Bush Lane, Cannon St., E.C.4.

Telegrams:—
Sun, Wellington, Salop.
Sunbrand (Cannon), London.

Telephone:—
11 Wellington, Salop.
5959 Central.

BARS, HOOPS, SECTIONS & WIRE
in IRON, STEED, COPPER and BRONZE.

Galvanised Telegraph, Telephone, Cable and Trolley Wire
To all Specifications.

Contractors to H.M. Government (Admiralty, G.P.O., India Office, War Office, Colonies), English and Foreign Railways, &c.

BEST H. C. COPPER & BRONZE WIRE a speciality.

Medals:—Sydney (Bronze) 1879, New Zealand (Gold) 1882, Liverpool (Silver) 1886, Adelaide (Gold) 1887, Franco-British Grand Prix (Highest Award) 1908.

WILLIAM JACKS & COMPANY,
WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

18, BENNETTS HILL, BIRMINGHAM.

11, OLD HALL STREET, LIVERPOOL.
EXCHANGE BLDGS., PORT TALBOT
5, MURZBAN ROAD, BOMBAY.
1, LALL BAZAR CALCUTTA.

1, HONG KONG ROAD, SHANGHAI
31, RAFFLES PLACE, SINGAPORE.
JAVA STREET, KUALA LUMPUR.
5 SHAFFRAZ ROAD, RANGOON.
COX'S BUILDINGS, KARACHI.

PIG IRON
SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.
IRON & STEEL SCRAP
COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM COLVIN & COMPANY,
ROYAL EXCHANGE, MIDDLESBROUGH.
93, HOPE STREET, GLASGOW.

SITUATIONS VACANT AND WANTED.

THE Lancashire Branch of the Institution of British Foundrymen beg to announce that several members, who have had varied experience as Foremen, etc., are at present disengaged. Employers who are in need of Foremen or other members of their foundry staff are invited to communicate with the Honorary Secretary, T. MAKEMSON, 21, Beresford Road, Stretford, Manchester

LATE PRODUCTION MANAGER of well-known firm desires position; experience in Engine and Ordnance Work, Colliery and General Engineering.—Apply, W. LAING, 4, Main Road, Handsworth, Sheffield.

A WELL-KNOWN PIG-IRON SALESMAN, with extensive international connection, opening London Offices New Year, desires representation of Cold Blast or similar Iron, Hematites, Scotch Pig-irons.—Box 310, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

WANTED, for an established steel works in the North of England, a Commercial Manager to take charge of Sales and the General Business of the Foundry. Experience with electric furnaces and large power station management an advantage. Output 25 tons per week; capable of large development. Good prospects for the right man.—Reply, with photo and full particulars of experience, references, age, and salary required, etc., to Box 308, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

WANTED.—Metallurgist for large Industrial Plant; must be conversant with the latest methods of heat treatment tempering and case hardening of steel; applicants should state qualifications, experience, past and present employers, which will be treated confidentially. — Address, "Metallurgist," WM. PORTEOUS & COMPANY, Advertising Agents, Glasgow.

WANTED.—FOUNDRY FOREMAN, experienced in moulding large marine castings and general heavy machine tool castings.—Apply, THE SHEEPBRIDGE COAL & IRON COMPANY, LIMITED, Chesterfield.

FOUNDRY FOREMAN wanted for London district; must have good knowledge of general machine castings, also thoroughly understands mixture of metals; no one unless thoroughly experienced need apply.—Reply, stating wage required, to Box 294, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

WANTED.—FOREMAN PATTERNMAKER, experienced in heavy marine engine, general machine tools and special pipe patterns.—Apply, THE SHEEPBRIDGE COAL & IRON COMPANY, LIMITED, Chesterfield.

PATENT.

ADVICE and Handbook Free.—KING'S PATENT AGENCY, LIMITED, Director, B. T. King, Reg. Patent Agent, 146a, Queen Victoria Street, E.C.4.

ADVERTISER is prepared to sell his Special Mixture and method of making Chilled Rolls. This process has been used successfully for over 20 years.—Further particulars, apply Box 306, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, Adelphi, Strand, London, W.C.2.

MACHINERY.

NINE nearly new Steel Hopper Wagons, standard gauge, roller bearings.

Two sets of Belt-driven Geared Hydraulic Pumps, 2-in. rams and 4-in. rams.

Brand new 4-ft. under-driven Sand Mill.

10-kw. Steam-driven Lighting Set, 110 volts D.C.; bargains.

HARRY H. GARDAM & COMPANY, LIMITED, STAINES.

"BREAKIR" Improved Foundry Sand Disintegrators and Mixers (capacities from one to ten tons per hour), obtain many improvements. Write for leaflets and quotations to the makers, W. BREALEY & COMPANY, LIMITED, Russell Street, Sheffield, or their Agents.

CASTINGS.

Modern Foundry equipped for weights up to 10 or 12 tons. Keen prices. Best quality.

Enquiries solicited for pattern making. Good deliveries.

Wm. ASQUITH (1920), Ld.

Highroad Wells Road - - - - HALIFAX

MACHINERY.—*Contd.*

New Hydraulic Brick Press, with rotary table, for making two magnesite bricks simultaneously, by Brinck & Hubner. Set of Three-throw Hydraulic Pumps, by Hathorn Davey & Company, rams 4¼ in. x 15 in. stroke, working pressure 1,500 lbs. Nearly new Vertical Three-throw Geared and Belt-driven Hydraulic Pump, by H. Berry & Company, 2½ in. rams, 6 in. stroke, working pressure 1,500 lbs. Horizontal Boring Machine, by The Lucas Machine Tool Company, 3 in. spindle, T-slotted table, 3 ft. 6 in. x 1 ft. 10 in. Horizontal Boring Machine, by J. Hetherington & Sons, Limited, 5½ in. spindle, front T-slotted bedplate 10 ft. 6 in. square. Ten nearly new 18 in. Centres All-geared Head, arranged for motor drive, S.S.S. Lathes on 34 ft. 3 in. bed, by G. & A. Harvey, Limited. 15 in. Centres Surface, Sliding and Screw-cutting Lathe, on 16 ft. straight bed, by Whitcomb-Blaisdell Company. 5 ft. Arm Double-geared Radial Drilling Machine, 3 in. balanced spindle, T-slotted box bed 3 ft. 7 in. by 3 ft. 27 in. stroke "Niles" Slotting Machine, worm- and rack-driven, table 4 ft. diam. 12 in. stroke Shaping Machine, quick return motion, two tables 21 in. x 13 in. x 13 in., by Jas. Archdale & Company, Limited.

Catalogue of Stock Machinery. 6,000 Lots.
Free on application. Inspection Invited.

THOS. W. WARD, LTD.,
ALBION WORKS,
SHEFFIELD.

MISCELLANEOUS.

COMPANY owning Steel and Non-Ferrous Foundry with Héroult Electric Furnace, well situated in Midlands, is desirous of increasing its capital with view to purchasing Works at present held on lease. The position of Secretary and two vacancies on Board of Directors are to be filled.—Inspection invited, and interested parties are asked to write for details to Box 300, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

The SIR JOHN CASS TECHNICAL INSTITUTE
JEWRY STREET, ALDGATE, E.C.3.
DEPARTMENT OF METALLURGY.

Head of Department ... GEO. PATCHIN, A.R.S.M., M.I.M.M.

The following special course of instruction will be continued during the Lent Term, 1923:—

FOUNDRY PRACTICE
(Ferrous and Non-Ferrous Metals)
by Geo. Patchin, A.R.S.M., M.I.M.M., and A. F. Gibbs.

Lectures and Practical Work, Monday Evenings, from 7 to 10 p.m., commencing January 8th, 1923.

A detailed syllabus of the course may be had upon application at the Office of the Institute, or by letter to the Principal.

FURNACES.

No. 6 Thwaites, good order	£90
No. 1 Greens cupolette with motor-driven fan ...	£35
120 lb. brass furnace cokefired, tilting, by Green ...	£28
600 " " " " " " Morgan	£60
240 " " " gasfired " Wright Morgan	£40
600 " " " " " " "	£60

SHANKS—NEW. in Stock.

10 cwt. Evans, £10	4 cwt. Sankey, £5
2 " Greens, £3	1 " Evans, £2 10s.

All complete with ladles, brand new.

MACHINES.

"Coventry" type head ram, NEW, by Britannia.	£25
"Pickles" type turnover by Evans, 18 in. x 18 in. ...	£22
EVANS flypress type for 12 x 12 boxes (2 in stock)	£12

Twenty others in stock, hand and pneumatic.

Send for complete list—the only stock of used foundry machinery in the country.

ALEX. HAMMOND,
Foundry Machinery Merchant, Boxted, SLOUGH.

To THE EDITOR of the Foundry Trade Journal.

Please send me details of the visit to the International Foundry Trade Congress and Exhibition to be held in Paris next September.

Name.....

Address.....

.....